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GRIZZLY BEAR HABITAT ANALYSIS

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GRIZZLY BEAR HABITAT ANALYSIS

Section II

EVALUATION OF GRIZZLY BEAR FOOD PLANTS, FOOD CATEGORIES AND HABITAT

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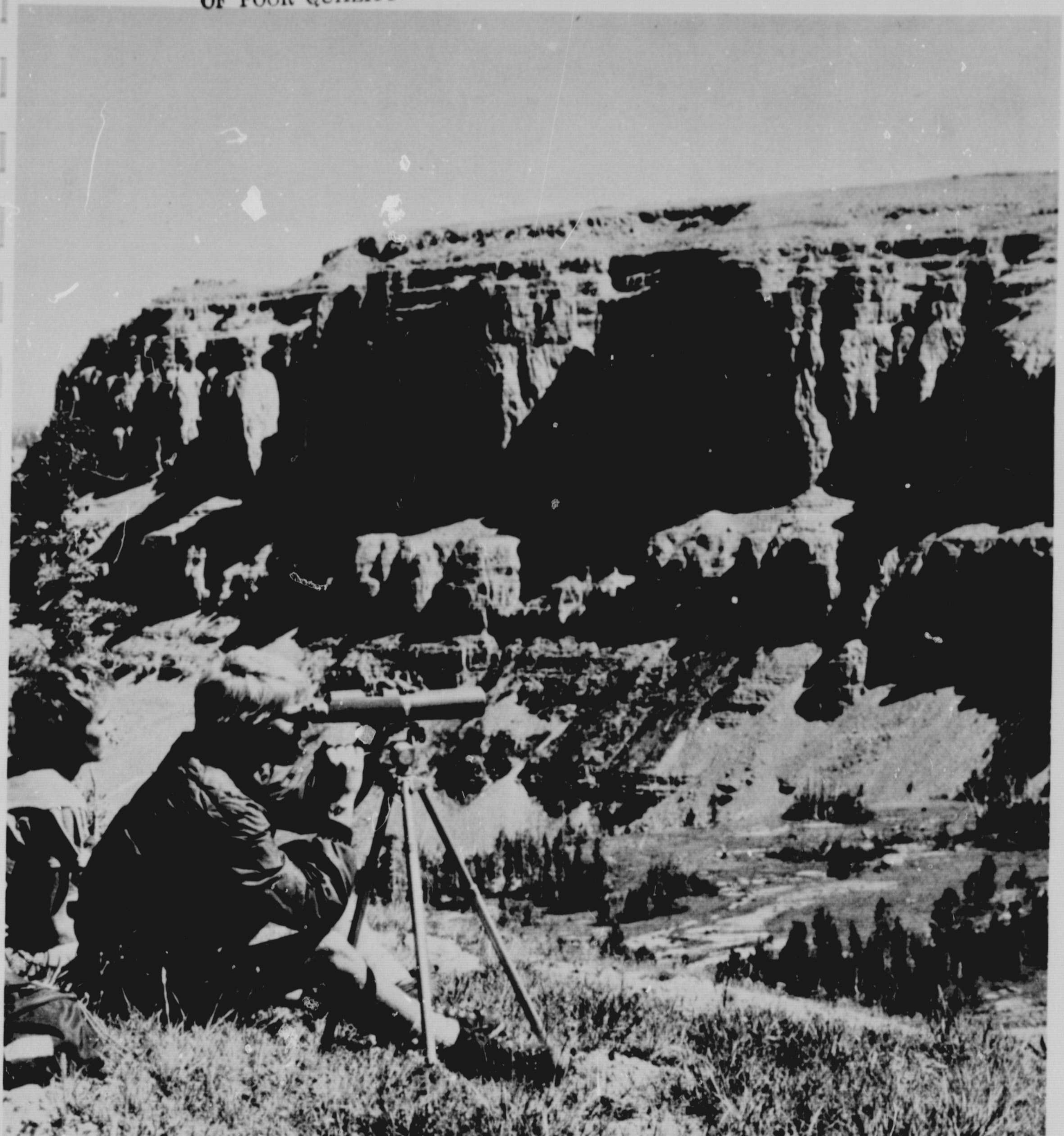

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INTRODUCTION

Section I dealt with descriptions and measurements of grizzly bear habitat as land units with their vegetation types. These were altitudinally grouped by climatic zones and each zone rated as a potential energy source, based on the abundance of food plants available to grizzly bears. In this section we attempt to refine the numerical values assigned to these energy sources by considering their actual use by bears. Values used to evaluate specific food plants and to prepare zonal habitat ratings were derived by analyzing the food habits of grizzlies in the area, evaluating the relative importance of specific food plants to the bears, and relating this information to the potential food plant abundance values derived in Section I. We will first analyse the bears' interactions with the plant food sources and then relate food consumption (diet) to food plant abundance, distribution, preference, energy values, and seasonal and annual availability.

Our objectives are to develop a better understanding of grizzly bears' feeding behavior and their use of plant energy. The results will be used in Section III as a data base to describe, map, and to evaluate grizzly bear habitat using LANDSAT multispectral imagery.

We must keep in mind that the grizzly is a carnivore. Between 50 and 60% of its diet is animal life varying in size from ants and moths to elk and bison. It is a predator, a scavenger, and on occasion, a cannibal. The grizzly is not a highly efficient predator and must utilize a wide range of plant foods. However, its feeding traits suggest that it would more frequently utilize the higher caloric animal foods if they were more readily available. The grizzly is directly dependent on the plant base as are other mammals that serve as food and cohabit the bears' environment. Therefore, an evaluation of the plant resource provides a reliable method for assessing the total environment for grizzlies. The grizzly, and other bears as well, have evolved efficient and complex feeding behaviors to take advantage of the high energy food plants. They have, therefore, adapted anatomically and physiologically to an omnivorous diet.

Mealey (1975) applied the economy concept of exchange between producers and consumers to explain grizzly bear feeding behavior in Yellowstone National

Park. He hypothesized three feeding economies based on feeding activity centers, viz., the valley plateau, mountain, and lake economies. This concept implies that individual grizzlies are confined to a specific economy or travel from one economy to another as energy sources become available. Our data on population size and distribution, movements, home and seasonal ranges, habitat use, and feeding habits of grizzlies in Yellowstone do not verify this theory (Craighead et al. 1960, Craighead, Varney and Craighead 1974, Craighead, F.C., Jr 1976, and Craighead, J.J. 1978). Our data gathered in Yellowstone and in the Scapegoat and Bob Marshall Wilderness areas, indicate that the annual feeding cycle follows plant phenology. Since the phenology is directly related to elevation (as modified by aspect, slope, moisture, exposure, and other factors), we have employed a climatic zone, rather than a feeding economies, concept. We believe it is a more appropriate concept for scientifically interpreting the interactions between grizzly bears and their food plant base. Accordingly, we have grouped and analyzed food habits data by season and by climatic zones.

Though grizzly bear habitat was mapped and described for three climatic zones in Section I, we confined our field observations and fecal sampling to the alpine and subalpine zones. Consequently, our analysis of food habits and feeding behavior will be limited to these two climatic zones except where relevant phenology and food plant abundance data for the temperate zone enable us to extend the scope of our analysis.

METHODS

Constraints on Fecal Analysis and Field Observation

Interpretation of the use of food sources from direct and indirect field observations and from the occurrence of diet items in fecal samples presents several problems. For example, discerning food habits by analysis of fecal samples necessitates a large sample over considerable time because of the great variety of possible food items and the temporal and spatial variations in food plant availability and abundance. In addition, some items identified in scats are less affected by digestive processes or degradation through weathering of scats than are others. Finally, it is often difficult to specifically identify the items (particularly forbs) isolated from a fecal sample.

To observe a feeding bear at a distance, to determine the plant species utilized and the degree of utilization, also has its limitations. Berries and certain forbs in the Scapegoat area could be more frequently identified to species than could grasses and sedges. Many observations yielded no conclusive data. Indirect evidence was even more fragmentary and difficult to quantify. Such evidence was considered only when adequate sign was present to indicate that digging for roots, stripping berries, or grazing a conspicuous forb was clearly the work of a grizzly bear. Much potential indirect information was discarded as inconclusive.

Observations of color-marked and radioed grizzlies in Yellowstone suggested that they exhibit feeding trends that are directly related to the availability of food sources within a prescribed biologic system. They also exhibit a wide range of individual preferences and food gathering habits that are conditioned by daily and seasonal availability of specific food items. Because grizzly bears establish home, seasonal, and life ranges and activity centers within these ranges, the food sources of individual animals and family groups are limited to the food sources within their respective ranges

(Craighead, J.J. 1978). Therefore, to obtain a representative sample of the diet items of a grizzly bear population inhabiting a large geographic area necessitates intensive spatial and prolonged temporal sampling.

Sampling techniques designed for statistical analysis are of limited value because of the difficulty in obtaining representative samples. The quality of observations necessary for quantifying highly variable data for statistical treatment is strictly specified and places severe constraints on the technique. The fecal data presented for the Scapegoat study area were the result of intense sampling and, because grizzlies tend to feed and drop their feces in localized sites, some diet items may be overemphasized and others underemphasized. The randomness needed for valid statistical analysis is not available. Nevertheless, the data do show feeding trends that can be used to evaluate energy sources. They also suggest general food sources and specific food plants that, with additional long-term sampling, may prove to be more important than our present analyses indicate. In spite of limitations recognized as inherent to fecal analyses, the data, when related to the abundance of food plants, their energy values, and other parameters, can be used to evaluate specific food plants and food plant categories and to refine the grizzly bear habitat evaluations developed in Section I.

Indications of Grizzly Bear Habitat Use

Use of the study area by grizzlies was documented by recording sightings, tracks, diggings, and scats (Table 1). Observation of grizzly bears was the most direct, but the most time-consuming, method of documenting their use of habitat. When bears were sighted, both direct and indirect information on food habits was obtained. Periods of observation for 39 sightings of grizzlies varied from a few minutes to over 9 hours and averaged 2 hours per sighting. One or more grizzlies were under constant observation by one or more observers for a total of 78 hours. Feeding sites were checked for diggings, scats, tracks, and beds following periods of observation. The duration of grazing and foraging activities were noted when specific food items could be identified. Grizzlies were observed generally at distances of 0.25 mile (0.4 km) or greater with 15-60 variable power spotting scopes and information was recorded on form sheets. Feeding sites were inspected to identify specific food plants utilized; the method

Table 1. Evidence of grizzly bear use of the alpine and subalpine zones, 1972-1976.

	Number of Sign or Sightings
Scats	282
Tracks	32
Diggings	121
Sightings	39
TOTAL	474

yielded qualitative, but seldom quantitative data.

Grizzly Bear Digging Areas

Digging areas are locations where grizzlies have dug for specific plant foods (Fig. 1). All such areas larger than 0.1 acre (0.04 ha) were measured, and information was recorded on altitude, date, location, habitat type, exposure, and numbers of tracks, scats, beds, and plants utilized. The age of each digging was estimated when animals were not observed.

Collection and Analysis of Grizzly Bear Scats

Scats collected in the study area during 1972-76 were located by research personnel when observing bears, backpacking, or mapping. Cylinder diameter was not considered a reliable criterion for distinguishing between grizzly and black bear (*Ursus americana*) scats because the wide range of age groups in both species result in a wide range in scat sizes. Therefore, scats were identified as being made by a grizzly only when located in known grizzly foraging or bedding areas or when definite grizzly sign (tracks or hair) were present (Fig. 2). This procedure greatly reduced our sample size, but virtually eliminated the possibility of

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Fig. 1 Typical grizzly bear digging area where bears excavated <u>Lomatium cous</u>: top, distant view; bottom, close-up view.

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Fig. 2 Upper-Grizzly bear feces composed largely of *Lomatium cous*. Scats were frequently found at the feeding sites. The roots and foliage of *L. cous* are displayed beside the scat. Lower-A grizzly bear track found by a food plant excavation site.

including black bear scats in the collection. Scats collected in the temperate zone were not analyzed because a sufficiently positive identification as to bear species was seldom possible.

Scats were individually categorized according to date of collection, climatic zone, habitat type, and estimated age. Each scat was placed in cheesecloth and air-dried in the field. A total of 282 scats were collected (Table 1). Scats composed largely of graminales and forbs were more easily located, but more difficult to age precisely, than those containing animal remains or berries. Being more durable, they are more frequently represented in the scat collection than is perhaps compatible with actual use of the plants by grizzlies. To test the durability factor, scats were examined after a year's exposure to the elements. Those composed of graminoids and forbs held their cylindrical form and were largely intact, while berry scats were too decomposed to be recognizable. Those composed of pine nuts had lost their form, but contents could be observed and collected.

Fecal analysis followed the procedures and techniques used by Tish (1961), Russell (1971), and Sumner and Craighead (1973). Individual scats were removed, teased, and screened onto dissecting trays. Plant species were identified and their percent composition by volume and percent occurrence recorded for each scat. Volumes of individual food items in each scat were summed to obtain a total diet volume.

The average volume per diet item is the average volume of a specific food item only for those scats in which it occurred, expressed as a percent. For example, Gramineae was found in 28.4% of the scats and comprised an average volume of 27.6% of those scats. Preference value for specific food plants and food plant categories is the sum of the average of all volume per diet items expressed as a percent and divided into each item value (see column 5, Table 2). The percent of diet volume was calculated by dividing the total volume of each specific food item by the total volume of all scats. For instance, the percent of diet volume for Gramineae was calculated by dividing 3721 by 15,962 to obtain the value of 23.3 (Table 2). The importance value (IV) for each diet item is the relative frequency of occurrence percent plus the percent of diet volume (Sumner and Craighead 1973). When calculated on a basis of 100% it becomes the importance value percent (IVP). The

Table 2. Frequency, Volume and Importance Value percents of food plant items found in 282 grizzly bear scats collected in the Alpine and Subalpine zones of the study areas, 1972-1976.

Food Items	Frequency of Occurrence	Frequency of Occurrence Percent	Relative Frequency of Occurrence Percent	Total Diet Volume	Average % Volume Per Diet Item	Preference Value	Percent of Diet Volume	Importance Value	Importance Value Percent	Energy Source (Plant Groups) IVP's
Graminales										
Gramineae	135	47.9	28.4	3721	27.6	7.0	23.3	51.7	25.9	29.7
Cyperaceae	23	8.2	4.9	413	18.0	4.6	2.6	7.5	3.8	
Forbs										
Unidentified	96	34.0	20.2	3426	35.7	9.0	21.5	41.7	20.9	
Claytonia megarhiza	31	11.0	6.5	700	22.6	5.7	4.4	10.9	5.5	
Equisetum arvense	20	7.1	4.2	70	3.5	.9	.4	4.6	2.3	
Lomatium cous	20	7.1	4.2	1010	50.5	12.8	6.3	10.5	5.3	
Claytonia lanceolata	9	3.2	1.9	75	8.3	2.1	.5	2.4	1.2	
Polygonum spp.	7	2.5	1.5	55	7.9	2.0	.3	1.8	.9	
Oxyria digyna	4	1.4	.8	35	8.8	2.2	.2	1.0	.5	37.6
Erythronium grandiflorum	3	1.1	.7	25	8.3	2.1	.2	.9	.5	
Cirsium scariosum	1	.4	.2	T	-	-	-	.2	.1	
Hedysarum spp.	1	.4	.2	T	-	-	-	.2	.1	
Juncus parryi	1	.4	.2	T	-	-	-	.2	.1	
Heracleum lanatum	1	.4	.2	T	-	-	-	.2	.1	
Agoseris spp.	1	.4	.2	T	-	-	-	.2	.1	
Berries										
Vaccinium spp.	16	5.7	3.4	1180	73.8	18.7	7.4	10.8	5.4	
Shepherdia canadensis	15	5.3	3.1	620	41.3	10.4	3.9	7.0	3.5	12.5
Fragaria spp.	14	5.0	3.0	145	10.4	2.6	.9	3.9	2.0	
Arctostaphylos uva-ursi	12	4.3	2.6	100	8.3	2.1	.6	3.2	1.6	
Ribes spp.	1	.4	.2	T	-	-	-	.2	.1	
Nuts										
Pinus albicaulis	63	22.3	13.2	4387	69.6	17.6	27.5	40.7	20.4	20.4
Total		168.5	99.8	15,962	394.6	99.8	100.0	199.8	100.3	100.3

Note: Volumes calculated as percent of scat volume.
Importance Value Percent = Importance Value ÷ Total of Importance Value Column

IVPs for individual food items were ranked and used to describe the dietary importance of food plants and their relationship to plant abundance and distribution though-out the entire study area. The methods for determining plant abundance (percent cover) and distribution (percent occurrence) were described in Section I.

We sampled root biomass for specific food plants by employing 3' x 3' (1 m x 1 m) quadrats in areas of high plant density. Roots (tubers, corms, or bulbs) were removed and these plus the excavated soil were computed in cubic centimeters. Roots were counted, and wet and oven-dry weights obtained.

Food Plant Energy Values

The quality of grizzly food plants in terms of available energy was estimated using standard proximate analysis to obtain percent moisture, protein, ether extract (fats), ash, and crude fiber (Crampton and Harris 1969). All analyses were performed by the Montana State University Chemistry Station. Nitrogen-free extract was determined by subtracting the weights of protein, water ash, crude fiber and ether extract from the original weight of the sample. This value, termed "difference", reflected any minor errors in the chemical analyses of the other five categories. In spite of this, the proximate analysis is useful to determine available energy for comparative purposes.

Total sugars were analyzed using the phenol sulphuric acid method (Dubois 1956). The non-sugar portion of the nitrogen-free extract was calculated by subtracting the percent sugar from the total nitrogen-free extract obtained from the standard proximate analysis.

Energy present in bear food plants was calculated in Kcal/g by multiplying the appropriate proximate analysis percent by the average caloric value for urea-free protein (4.3 Kcal/g), ether extract (9.4 Kcal/g), and carbohydrates (4.2 Kcal/g). Average caloric values for proteins, fats, and carbohydrates were obtained from Schmidt-Nielsen (1975). Crude fiber was not assigned a value. Because microorganisms necessary for digestion of cellulose, the major component of crude fiber, have not been demonstrated from the bears' digestive tract, it is unlikely that appreciable amounts of energy were available from crude fiber. Crampton and Harris (1969) believe the digestability of crude fiber is generally underestimated and show digested percents varying from 3-25 in pigs and from 25-62 in man. However, until such information is available from physiological experiments with live bears, suppositions as to energy available from crude fiber should not be included.

Chemical analysis showed that plant forage specimens collected early in the growth season contained different percentages of proteins, fats, and carbohydrates than did mature specimens. Mealey (1975) found protein levels in green forage plants to be much higher during the succulent stages than during the post-flowering stages. Our analyses consider forage plants in the succulent stage of growth. Future analyses should include specimens in all developmental stages.

RESULTS

Importance Value Percents

Food plant items identified in 282 grizzly bear scats were separated from the animal content and ranked in terms of frequency and volumetric percentages to determine their dietary importance. Percentage values of food plants found in scats could then be related to percentage values of food plant abundance within the study area. The percent vegetation cover values discussed in Section I are essentially plant abundance values. The terms "abundance" or "percent abundance" will be used in lieu of "percent cover" throughout this section.

As suggested earlier, quantitative values derived from scat analysis must be interpreted cautiously. The importance value percent (IVP), a value developed by Sumner and Craighead (1973) to relate frequency of occurrence of food plants in scats to their percent volume in scats, is useful for showing food habit trends. For a specific food plant or food category, it becomes a much more accurate interpretive tool when related to the abundance, distribution, and available energy content of the food plant species or category within a specific study area. Such information will be used to analyze grizzly bear food habits and energy sources. Data on animal food items have been purposely deleted from Table 2 and will be treated in a separate paper.

Among the plant food energy sources, graminales, forbs, berries, and pine nuts have collective IVPs of 29.7, 37.6, 12.5, and 20.4, respectively. These are the four major plant energy sources for the bear (Table 2).

Species of grasses and sedges were difficult to distinguish and specific IVPs were not obtained for each. Grizzlies generally appear to consume grasses and sedges largely on a basis of availability, but additional data will probably show a decided preference for certain species. The IVP values were demonstrated specifically for many plant food items, ranging from 20.4 for pine nuts (Pinus albicaulis) to 0.1 for several forb species. However, the remains of many forbs could not be specifically identified and were lumped as unidentified. The IVP value for these was high (20.9). The IVPs for the identified forbs suggest selective feeding. The low IVP values for specific berries do not appear to be consistent with the observed preference grizzlies exhibited toward these foods. In short, IVPs must be related to other parameters for interpretive purposes. We intend to use them as a basis for making value judgements on the relative importance of the four food plant energy sources and of specific food plants as well.

Relation of Importance Value Percent to General Food Plant Abundance Values

Food plant abundance values for the alpine and subalpine zones were compared with their corresponding importance value percents (Tables 3 and 4). The IVPs were uniform throughout the two climatic zones; while the food plant abundance values were specific for each zone and were combined for purposes of comparison.

Table 3. Comparison of food plant utilization by grizzlies to food plant abundance in the Grass-Shrublands of the Alpine and Subalpine Zones.

Food Items	Food Plant Utilization: Percent of Diet Volume	Food Plant Utilization: Importance Value Percent	Food Plant Abundance, Percent Vegetation (Cover)**: Alpine Zone	Food Plant Abundance, Percent Vegetation (Cover)**: Subalpine Zone	Food Plant Abundance, Percent Vegetation (Cover)**: Combined*** Both Zones
Graminales					
Gramineae	23.3	25.9	18.1	18.7	18.4
Melica spectabilis	ob.*	-	0	T	T
Cyperaceae	2.6	3.8	19.9	13.1	16.4
Forbs and Shrubs					
Unidentified	21.5	20.9	-	-	-
Claytonia megarhiza	4.4	5.5	.3	0	.2
Equisetum arvense	.4	2.3	0	1.2	.6
Lomatium cous	6.3	5.3	.7	.6	.6
Claytonia lanceolata	.5	1.2	.1	.8	.4
Polygonum spp.	.3	.9	1.0	.3	.7
Oxyria digyna	.2	.5	T	0	T
Erythronium grandiflorum	.2	.5	.9	1.0	1.0
Cirsium scariosum	T	.1	.1	.1	.1
Hedysarum spp.	T	.1	1.5	.2	.9
Juncus spp.	T	.1	1.6	.5	1.1
Heracleum lanatum	T	.1	T	1.1	.5
Agoseris spp.	T	.1	T	T	T
Xerophyllum tenax	ob.	-	0	12.1	5.9
Osmorhiza occidentalis	ob.	-	0	.9	.4
Lomatium dissectum	ob.	-	0	.2	.1
Angelica dawsonii	ob.	-	0	T	T
Perideridia gairdneri	ob.	-	0	T	T
Hieracium spp.	ob.	-	0	T	T
Berries					
Vaccinium spp.	7.4	5.4			
Vaccinium scoparium	-	-	1.1	3.2	2.1
Vaccinium globulare	-	-	0	.6	.3
Arctostaphylos uva-ursi	.6	1.6	5.3	.1	2.8
Shepherdia canadensis	3.9	3.5	0	.5	.2
Amelanchier alnifolia	ob.	-	0	.1	T
Lonicera involucrata	ob.	-	0	.1	T
Rubus parviflorus	ob.	-	0	.1	T
Berberis repens	ob.	-	0	T	T
Ribes lacustre	.1	-	.1	T	T

*ob. = Direct and indirect evidence of use but not represented in scats.
T = Trace
**Measurements of percent cover. See Section I.
Total Plots = 282
***An average of plot data - not an average of percents.

Table 4. Comparison of food plant utilization by grizzlies to food plant abundance in the Coniferous Forests of the Subalpine Zone. (HT-831-820-832-850).

Food Item	Food Plant Utilization: Percent of Diet Volume	Food Plant Utilization: Importance Value Percent	Food Plant Abundance ** Subalpine Coniferous Forests
Berries			
Vaccinium spp.	7.4	5.4	
V. scoparium			32.4
V. globulare			.2
Shepherdia canadensis	3.9	3.5	.1
Fragaria virginiana	.9	2.0	.2
Ribes lacustre	T		.1
Rubus parviflorus	ob.*	-	T
Lonicera involucrata	ob.	-	T
Graminales			
(Gramineae)	23.3	25.9	
Calamagrostis rubescens	-	-	T
Calamagrostis canadensis	-	-	T
Festuca idahoensis	-	-	T
(Cyperaceae)			
Carex geyeri	2.6	3.8	7.0
Forbs			
Cirsium scariosum	T	.1	T
Heracleum lanatum	T	.1	.3
Erythronium grandiflorum	.2	.5	T
Xerophyllum tenax	ob.	-	19.2
Hedysarum occidentale	ob.	-	.1
Claytonia lanceolata	ob.	-	T
Lomatium dissectum	ob.	-	T
Nuts			
Pinus albicaulis	27.5	20.4	17.0

*ob. = Direct and indirect evidence of use but not represented in scats.
T = Trace

**measurement of percent cover. See Section I
Total plots 285

Grass-Shrublands

The relationships between IVPs and food plant abundance provided numerous interpretive insights. For example, the high IVP of grasses (25.9) and their high average abundance (18.4%) in the Grass-Shrublands of both the alpine and subalpine zones may indicate that grasses are consumed because they are readily available (Table 3). Sedges, on the other hand, with an abundance value similar to that of the grasses (16.4%) but with a relatively low IVP (3.8), are equally available, but less preferred.

Among the forbs of the Grass-Shrublands, Claytonia megarhiza had an IVP of 5.5. The species is confined to the alpine zone where it had an abundance value of 0.3%. Throughout both climatic zones it would rate an average abundance value of only 0.2%. It was utilized out of all proportion to its general abundance, indicating that grizzlies have a high preference for it. Lomatium cous rated an IVP of 5.3. This food plant, found in both climatic zones, is relatively abundant (0.6%) compared to other forbs used as food. However, compared to the grasses and sedges, it was a scarce item of food, a fact which suggests that grizzlies must locate it selectively.

Species of Polygonum have a low IVP (0.9) compared to that of Lomatium (5.3), but both generally have comparable abundance values. This suggests that Polygonums were not preferred foods, a conclusion supported by direct observation of feeding behavior.

Erythronium grandiflorum, Heracleum lanatum, and species of Juncus have relatively low IVPs, but comparatively high abundance values (Table 3). Thus, these food plants were not consumed in amounts proportional to their abundance values in the alpine and subalpine zones. This may indicate that they were either low in order of preference or were difficult for bears to locate, or, as in the case of H. lanatum, received maximum use in the temperate zone.

Xerophyllum tenax was rarely eaten by grizzlies, yet it had a very high average abundance value (5.9%) compared to other forbs of the alpine and subalpine zones. Though absent in the alpine zone, it had an abundance rating of 12.1% in the subalpine. The developing seed pods and developing flower heads are utilized, but the leaf base probably serves only as a marginal food when more preferred foods are scarce or unavailable.

Arctostaphylos uva-ursi ranked among the more heavily utilized shrubs with an IVP of 1.6 and an average abundance value of 2.6% for both zones and 5.3% for the alpine zone. Berries, but not the forage, were eaten. Other berries of the Grass-Shrublands had much higher abundance values in the coniferous forests (Table 4) and will be discussed in subsequent paragraphs.

We conclude that a general relationship exists between grizzly bear use of the grass and forb plant food categories and the abundance values of these plants in the Grass-Shrublands of the alpine and subalpine zones. Sedges, however, were not consumed in amounts reflecting their high relative abundance values.

Data indicate a general relationship between the use of specific forbs and their abundance values; however, some very abundant species were only lightly used while some scarce species were heavily used (Tables 3 and 4). This suggests that preference and a high order of selectivity, as well as availability, are involved in the feeding habits of grizzly bears. We will later attempt to describe factors, other than abundance, which affect or modify the importance value percent.

Coniferous Forest

Berries and pine nuts were the primary energy sources for grizzlies in forest habitat types; grasses, sedges, and forbs were secondary. Many food plants found in the Grass-Shrublands were also undergrowth plants in coniferous forests; similarily the berry-producing shrubs and forbs, so abundant in certain forest habitat types (Section I), were also present in the Grass-Shrublands. The IVPs of food plants were compared to their abundances in four forest habitat types of the subalpine zone (Table 4) to analyze trends in the relationship between feeding by bears and plant availability.

The high IVP for grasses (25.9) when compared to their low abundance values (trace representation for Calamagrostis rubescens, C. canadensis, Festuca idahoensis and other grasses), suggests that the subalpine coniferous forests were not the major grazing areas for grizzlies. The relatively low abundance values for sedges and for forb food plants compared to their abundance in the Grass-Shrublands further support this conclusion (Tables 3 and 4).

Vaccinium scoparium was far more abundant in the confierous forest habitat types than in the Grass-Shrublands. The berries of V. scoparium and V. globulare have a combined IVP of 5.4. This is low compared to the grass and forb categories, but high for a specific food item.

The abundance of V. scoparium (Table 4), indicates that utilization is related to its general abundance, perhaps irrespective of annual fluctuations in berry production.

The relatively high IVPs for Shepherdia canadensis and Fragaria spp., both of which have low abundance values, may reflect learned behavior patterns (reinforced by memory) whereby grizzlies selectively seek scarce, but preferred, food items year after year in remembered locales.

Pinus albicaulis showed an IVP of 20.4 and also had a high abundance value (17.0%). However, like the Vacciniums, the seed crop of P. albicaulis is highly variable.

Relation of IVPs to Selected Food Plant Abundance Values

It was apparent from field observation and scat analysis that grizzlies tended to feed in areas of high plant food density. Therefore, there should be a more direct relation between a food plant's IVP and its abundance value at sites of its highest density, than between its IVP and its general or random abundance value. Accordingly, some important food plants were sampled at selected high density sites. We termed the values obtained the "selected abundance values". Data for 5 of the more important species of forb in the Grass-Shrublands of the alpine and subalpine zones and 3 shrub, 1 forb, and 1 tree species in the coniferous forest of the subalpine zone were gathered (Tables 5,6, and 7). Grasses and sedges were sampled in both zones.

Grass-Shrublands of the Alpine and Subalpine Zones

Random and selected abundance and distribution values for some of the important food plants of the Grass-Shrublands of both climatic zones were compared with IVPs for the same plants (Tables 5 and 6).

The random abundance value of 0.3% for Claytonia megarhiza (Table 5) is its abundance (percent vegetation cover) relative to the abundance of all other grasses, forbs and shrubs sampled in the alpine zone. The selected value of 41.4% is its abundance relative to other alpine plants in locales where C. megarhiza was a predominant member of the plant community. The random value represents the abundance of C. megarhiza among all other alpine species recorded in 159 plots taken randomly throughout the alpine zone. The selected value represents its abundance among a more limited range of species recorded in 30 plots taken only on rocky talus slopes at 8500 feet and higher. The same sampling and evaluation prodecure was used for

Table 5. Comparison of importance value percent with percent abundance and percent occurrence of some preferred bear food plants in the Grass-Shrublands of the alpine zone.

		Percent Vegetation Abundance				Percent Occurrence	
Food Item	I.V.P.	Number Random Plots	Random Values	Number Selected Plots	Selected Values	Random Values	Selected Values
Claytonia megarhiza	5.5	(159)	.3	(30)	41.4	1.9	100.0
Polygonum spp.	.9	(159)	1.0	(15)	8.0	8.8	100.0
Lomatium cous	5.3	(159)	.7	(15)	20.7	6.3	100.0
Gramineae	25.9	(159)	18.0	(10)	63.0	45.3	100.0
Cyperaceae	3.8	(159)	19.9	(10)	62.0	52.2	100.0

all species and plant groupings presented in Tables 5, 6, and 7.

Alpine Zone

Claytonia megarhiza had the highest IVP (5.5) among the more important forb food plants of the alpine zone (Table 5). In 159 random plots this food plant represented only 0.3% of the total cover and occurred in only 1.9% of the plots. While it was neither abundant nor widely distributed, its importance value percent was found to be high. Grizzlies used this plant by finding those locales where it was abundant and returning periodically to feed. Once this food plant was located, bears fed intensively and, at times exclusively, on it, thereby indicating highly developed food-finding behaviors rather than opportunistic ones. The same phenomenon occurred with the Lomatiums, especially *L. cous*. This plant was neither abundant nor widely distributed in the Grass-Shrublands of the alpine or subalpine zones, yet it had an IVP of 5.3. On selected sites, *Lomatium cous* comprised 20.7% of the plant cover. It was primarily on such sites that we observed bears excavating the roots.

Respecting the Polygonums, the situation was reversed. *Polygonum bistortoides* and *P. viviparum* were more generally abundant and widely distributed in the alpine zone than were C. megarhiza or L. cous, but were not often found locally concentrated (Table 5). A low IVP of 0.9 suggests they were not preferred food items nor were they selectively sought.

Grasses were extremely common, with random and selected abundance values of 18.0 and 63.0%, respectively (Table 5). Though grizzlies probably exhibit preference for certain species, the extremely high IVP of 25.9 for this food category, as indicated earlier, appears to be directly related to its high abundance values. The comparatively low IVP of 3.8 for the sedge category, with random and selected abundance values of 19.9 and 62.0%, respectively (Table 5), imply that abundance may not have been an important factor influencing its utilization, even where abundance approached 100%. Where grasses are equally abundant, they appear to be preferred over sedges. Seasonal succulence may be a factor accounting for the difference.

Subalpine Zone

None of the forbs were generally abundant, as indicated by their random values, but many were abundant in selected locales (Table 6). The data suggest that grizzlies

Table 6. Comparison of importance value percent with percent abundance and percent occurrence of some preferred bear food plants in the Grass-Shrublands of the subalpine zone.

		Percent Vegetation Composition				Percent Occurrence	
Food Item	I.V.P.	Number Random Plots	Random Values	Number Selected Plots	Selected Values	Random Values	Selected Values
Erythronium grandiflorum	.5	(123)	1.0	(15)	14.9	7.3	100.0
Claytonia lanceolata	1.2	(123)	.8	(15)	18.5	6.5	100.0
Lomatium cous	5.3	(123)	.6	(25)	41.3	7.3	100.0
Gramineae	25.9	(123)	18.7	(10)	66.5	72.3	100.0
Cyperaceae	3.8	(123)	13.1	(10)	43.0	55.3	100.0

exhibited a preference for the Lomatiums over *Erythronium grandiflorum* and *Claytonia lanceolata* when all occurred together at relatively high densities. Whether this might be a taste or food-gathering preference will be discussed later.

As in the alpine zone, grasses had high random and selected abundance values (18.7 and 66.5%, respectively) and were heavily utilized. Also, sedges showed comparable abundance values (13.1 and 43.0%), but were once again only lightly utilized.

Coniferous Forests of the Subalpine Zone

Grizzlies tended to utilize the *Vaccinium* spp. in proportion to both their random and selected abundance values, but no such relationship was evident for the patchily distributed and generally less common *Shepherdia canadensis* and *Fragaria* spp. (Table 7). This does not mean that grizzlies did not deliberately seek sites where the berries of the Vacciniums were most abundant, but rather that, because of their general abundance and distribution, the Vacciniums were encountered and the berries eaten on an opportunistic basis as well. The berries of *S. canadensis* and *Fragaria* spp., on the other hand,

Table 7. Comparison of importance value percent with percent abundance and percent occurrence of four preferred bear food plants (berries) in the coniferous forests of the Subalpine Zone.

Species	I.V.P.	Percent Vegetation Composition				Percent Occurrence	
		Number Random Plots	Random Values	Number Selected Plots	Selected Values	Random Values	Selected Values
Vaccinium scoparium	5.4	(323)	32.6	(20)	68.0	55.7	100
Vaccinium globulare		(323)	.2	(20)	34.5	17.3	100
Shepherdia canadensis	3.5	(323)	.1	(20)	26.7	7.4	100
Fragaria virginiana	2.0	(323)	.2	(20)	6.5	4.6	100

required of the bears a much more selective process. It is difficult to otherwise account for the high IVPs in relation to the low abundance values.

Seasonal Use of Food Categories

Seasonal use of specific food items was determined through analysis of scats (Table 8). Among the forbs, *Claytonia megarhiza* and *Lomatium cous* had only summer use, while *C. lanceolata* and *Erythronium grandiflorum* had only spring use. Among the berries, *Arctostaphylos uva-ursi* was utilized throughout the spring, summer, and fall periods. This "year round" use occurs because the berries are persistent and occur throughout the entire altitudinal range of the bear's habitat. The *Vaccinium* spp., *Shepherdia canadensis*, and *Fragaria* spp. showed summer utilization only; however, direct observation confirmed fall use, as well.

The seasonal availability of the four energy source categories (Grass-sedge, Forbs, Berries, Pine nuts) govern, to a large extent, the grizzly bear's feeding behavior, movements, and seasonal feeding cycle (Table 9 and Fig. 3).

Whitebark pine seeds were found in 95% of the fall-

Table 8. Frequency of occurrence by season of food plant items found in 282 grizzly bear scats collected in the Alpine and Subalpine Zones of the study area. 1972-1976.

Food Items	SPRING (5-1 to 6-30) (42 scats) Frequency of Occurrence	Frequence of Occurrence Percent	SUMMER (7-1 to 8-30) (203 scats) Frequency of Occurrence	Frequency of Occurrence Percent	FALL (9-1 to 10-30) (37 scats) Frequency of Occurrence	Frequency of Occurrence Percent	Totals (282 scats) Frequency of Occurrence	Frequency of Occurrence Percent
Graminales								
Gramineae	17	40.5	113	55.7	5	13.5	135	47.9
Cyperaceae	10	23.8	13	6.4	0	0	23	8.2
Forbs								
Unidentified	9	21.4	87	42.9	0	0	96	34.0
Claytonia megarhiza	0	0	31	15.3	0	0	31	11.0
Equisetum spp.	0	0	20	9.9	0	0	20	7.1
Lomatium spp.	0	0	20	9.9	0	0	20	7.1
Claytonia lanceolata	1	2.4	7	3.4	1	2.7	9	3.2
Polygonum spp.	0	0	7	3.4	0	0	7	2.5
Oxyria digyna	0	0	4	2.0	0	0	4	1.4
Erythronium grandiflorum	3	7.1	0	0	0	0	3	1.1
Cirsium scariosum	0	0	1	.5	0	0	1	.4
Hedysarum spp.	0	0	1	.5	0	0	1	.4
Juncus parryi	0	0	1	.5	0	0	1	.4
Heracleum lanatum	0	0	1	.5	0	0	1	.4
Agoseris spp.	0	0	1	.5	0	0	1	.4
Berries								
Vaccinium spp.	0	0	16	7.9	0	0	16	5.7
Shepherdia canadensis	0	0	15	7.4	0	0	15	5.3
Fragaria spp.	0	0	14	6.9	0	0	14	5.0
Arctostaphylos uva-ursi	1	2.4	10	4.9	1	2.7	12	4.3
Ribes spp.	0	0	1	.5	0	0	1	.4
Nuts								
Pinus albicaulis	16	38.1	12	5.9	35	94.6	63	22.3

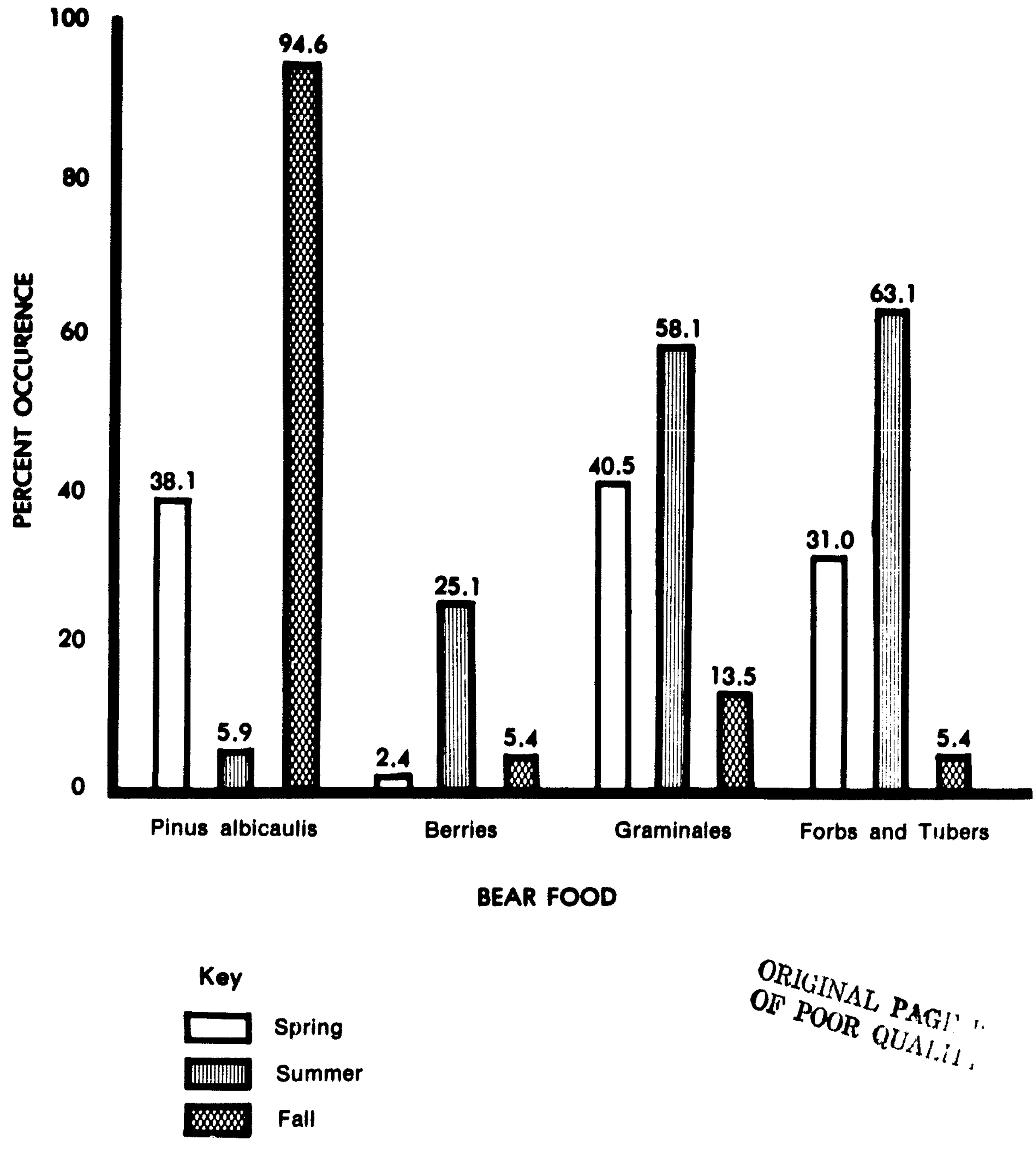
Table 9. Frequency of occurrence by season of four major food plant categories found in 282 grizzly bear scats collected in the study area. 1972-1976.

	SPRING (5-1 to 6-30)*		SUMMER (7-1 to 8-30)		FALL (9-1 to 10-30)			
	Occurrence		Occurrence		Occurrence		Occurrence	
Food Category	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Pinus albicaulis	16	38.1	12	5.9	35	94.6	63	22.3
Berries	1	2.4	51	25.1	2	5.4	54	19.1
Graminales	17	40.5	118	58.1	5	13.5	140	49.6
Forbs	13	31.0	128	63.1	2	5.4	143	50.7

Note: Frequency of occurrence of food categories shown in this table is less than frequency of occurrence in Table 3 listing the species within the category. This is becuase in some instances two or more specific items occurred in a single scat but represented a single category and therefore are recorded here as a single occurrence.

*Periods designated as spring, summer, and fall refer to the time spans shown above. They were phenologically determined.

Fig. 3 Seasonal variation in percent occurrence of four plant food categories recorded from 282 grizzly bear scats.



100
80
60
40
20
0
PERCENT OCCURENCE
94.6
38.1
5.9
2.4
25.1
5.4
40.5
58.1
13.5
31.0
63.1
5.4
Pinus albicaulis
Berries
Graminales
Forbs and Tubers
BEAR FOOD
Key
Spring
Summer
Fall

collected scats and were well-represented in those collected in spring. During years when seed production was high, pine nuts were still available in spring on the forest floor and in animal caches.

Berries were almost exclusively summer-fall food items (Table 9 and Fig. 3). The most abundant and widely distributed species of berries were the Vacciniums. Their berry crops fluctuated widely from year to year and from one locale to another during a given year. Berry productions appear to peak about every third to fourth year, but more research is necessary to precisely define and describe these fluctuations. When berries of the Vacciniums are abundant, they are consumed to the exclusion of most other available plant food items.

Grasses are primarily spring and summer foods, (Table 9 and Fig. 3) but even in fall when they have lost succulence, they may constitute an important item of diet, especially in years when pine nuts or berries are scarce. Sedges are consumed primarily in spring and early summer when succulent, with use declining in summer as they mature. The grasses and sedges did not exhibit marked annual fluctuations in distribution or abundance and thus, constituted a highly stable energy source. Because grasses and sedges were so generally abundant and well-represented in all climatic zones, the seasonal variations in biomass that did occur had little observable effect on seasonal use by grizzlies. At no time during the forage year was there a serious scarcity of this food catetory in the study area. (This situation, of course, might not apply to areas supporting high livestock or wild ungulate populations.) Because of their general abundance and seasonal availability, grasses and sedges were especially important as energy sources at low elevations in spring and at high elevations in summer. Forbs, like the grasses and sedges, are chiefly spring and summer foods (Table 9 and Fig. 3). As a group, they too are abundant, widely distributed and subject to comparatively minor annual or seasonal variations in availability. The relative decrease in use during the fall is probably associated with a decrease in succulence and palatability, as well as with an increase in the availability of more preferred foods such as pine nuts and berries.

Food Preference Indicator

The average volume of an item of diet found in scats (Table 2) can be interpreted as an indication of preference. For example, the value of 27.6% for Gramineae indicates that grasses were frequently eaten along with other items of diet, whereas Vaccinium berries and pine nuts with values of 73.8 and 69.6%, respectively, were eaten in quantity and exclusive of other less desirable, but available, foods. The grizzly tends to make an entire meal on the more highly preferred foods. This relationship is shown in Fig. 4 where the average percent volume per diet item for Gramineae is compared with this value for *Lomatium cous*, *Vaccinium* spp., and the seeds of *Pinus albicaulis*.

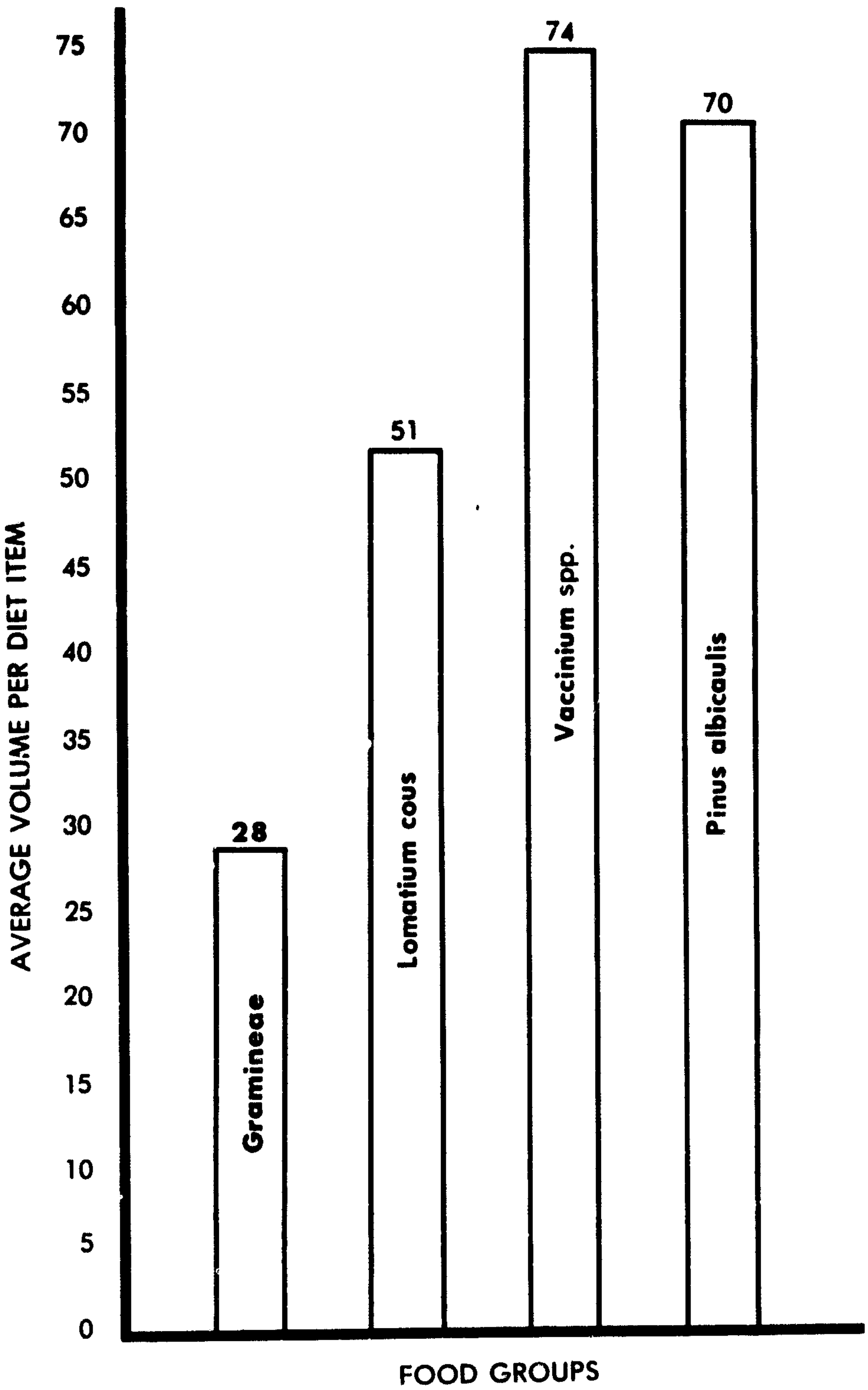
A preference value percent (PVP) was obtained by dividing the average percent volume per diet item for each plant by the total for all plants. The PVP will be used in subsequent text to express the quantitative food preferences of grizzly bears.

Food Plant Energy and Nutritive Values

We have discussed how abundance, distribution, and variations in the availability of food plants may affect the food habits of bears. Total available energy of specific plant foods is also a factor to be considered.

Considerable evidence is found in the literature

Fig. 4 Average volume per diet item of four plant foods utilized by grizzly bears. This relationship was used to develop a preference value. The relative preference of the four food groups are *Vaccinium* spp. 1; *Pinus albicaulis* 2; *Lomatium cous* 3; and Gramineae 4.



AVERAGE VOLUME PER DIET ITEM
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
28
Gramineae
51
Lomatium cous
74
Vaccinium spp.
70
Pinus albicaulis
FOOD GROUPS

indicating that many of the large herbivores exhibit decided preferences for high energy food plants and are extremely selective in the portions of a plant they consume. The grizzly bear, though a carnivore, appears to show such tendencies, also. Our observations of the bears' food habits in Yellowstone National Park from 1959 through 1970 showed that they consumed tubers, roots, and bulbs high in carbohydrates, and emergent greens such as sedges and forbs that were high in protein. We hypothesized that a factor determining food selection was total energy content. To further clarify this observation, we had a number of food plants anaylzed in 1968 by the Montana State University Chemistry Station to determine energy values. The results supported our hypothesis. Mealey (1975), following up on our results, also obtained positive evidence of selective utilization of high energy plants.

Energy (Kcal/g) accruing to proteins, ether extract (fats), and nitrogen-free extract (carbohydrates) found from some of the more important food plants occurring in the Scapegoat study area was determined (Table 10). Available energy of specific food plants varied from a low of 1.91 Kcal/g in the roots of *Veratrum veride* to 3.99 Kcal/g

Table 10. Chemical analysis and caloric values of grizzly bear food plants.

Bear Food Plant	No. Samples	Protein Percent	Protein Kcals/g	Ether Extract Percent	Ether Extract Kcals/g	Nitrogen Free Extract Sugars %	Nitrogen Free Extract Non-Sugars %	Total Nitrogen Free Extract Percent	Total Nitrogen Free Extract Kcals/g	Percent Total Kcals/g	Energy Value Percent (EVP)
Graminales [illegible]liage, bulbs)											
Cyperaceae											
Carex (leaves & leaf base)	3	11.31	.49	2.27	.21	4.80	33.37	38.17	1.60	2.30	1.[illegible]
Gramineae											
Calamagrostis rubescens (leaves)	1	6.00	.26	3.15	.30	4.70	35.38	40.08	1.68	2.24	1.9
Festuca idahoensis (leaves)	1	3.30	.14	1.60	.15	-	-	41.40	1.74	2.03	1.7
Melica spectabilis (bulblets)	1	2.80	.12	1.30	.12	-	-	71.90	3.02	3.26	2.7
Average Gramineae		(4.03)	(.17)	(2.02)	(.19)	(4.70)	(35.38)	(51.13)	(2.15)	(2.51)	(1.[illegible])
Average Graminales		(5.85)	(.25)	(2.08)	(.20)	(4.75)	(34.38)	(47.89)	(2.01)	(2.46)	(2.1)
Forbs (foliage, bulbs)											
Perideridia gairdneri (tubers)	1	3.40	.15	.70	.07	-	-	80.71	3.39	3.61	3.0
Equisetum arvense (foliage)	2	11.58	.50	3.97	.37	8.40	32.39	40.70	1.71	2.58	2.2
Xerophyllum tenax (seed pods)	1	14.76	.63	15.64	1.47	5.40	34.21	39.61	1.66	3.76	2.5
Xerophyllum tenax (leaf base)	2	3.86	.17	1.25	.12	7.20	40.03	47.23	1.98	2.27	
Claytonia lanceolata (corms)	2	6.80	.29	.66	.06	-	-	77.05	3.59	3.94	3.3
Erythronium grandiflorum (bulbs)	2	[illegible].50	.15	.44	.04	-	-	81.88	3.44	3.63	3.0
Lomatium cous (roots)	5	.80	.25	2.59	.24	-	-	50.08	2.10	2.59	2.2
Heracleum lanatum (foliage)	3	[illegible].14	.39	2.40	.23	7.90	38.39	45.40	1.91	2.53	2.1
Hedysarum occidentale (root)	1	9.53	.41	1.54	.14	3.90	30.14	34.04	1.43	1.96	1.7
Polygonum bistortoides (root)	2	7.00	.30	1.00	.09	-	-	47.80	2.01	2.40	2.0
Claytonia megarhiza (root)	1	18.80	.81	1.80	.17	-	-	36.80	1.55	2.53	2.1
[illegible]rsium scariosum (root)	1	7.20	.31	.90	.08	-	-	61.30	2.57	2.96	2.5
Luzula hitchcockii (leaves)	1	9.04	.39	2.17	.20	8.60	42.48	50.48	2.12	2.71	2.3
Trifolium repens (foliage)	1	15.43	.66	2.64	.25	10.80	33.66	44.46	1.89	2.80	2.3
Osmorhiza occidentalis (root)	1	9.18	.39	4.57	.45	11.50	34.86	46.36	1.95	2.79	2.3
Veratrum viride (root)	1	7.93	.34	.94	.09	1.40	33.81	35.21	1.48	1.91	1.6
(Average) Forbs		(9.30)	(.40)	(2.83)	(.27)	(7.17	(35.55)	(49.23)	(2.09)	(2.81)	([illegible].3)
Shrubs and Forbs (berries)											
Vaccinium globulare	2	3.98	.17	3.30	.31	38.00	27.01	65.16	2.74	3.22	2.8
Vaccinium scoparium	2	6.91	.30	4.70	.44	40.00	26.23	66.23	2.78	3.52	
Fragaria virginiana	1	8.90	.38	3.68	.35	25.00	28.24	53.44	2.24	2.97	2.5
Ribes cereum	2	5.21	.22	3.40	.32	33.60	32.13	65.73	2.76	3.30	2.8
Shepherdia canadensis	1	9.40	.40	3.05	.29	34.00	27.13	61.13	2.57	3.26	[illegible].7
Rubus sp.	1	5.49	.24	3.63	.34	22.30	31.06	53.36	2.24	2.82	2.4
Ribes lacustre	1	5.61	.24	3.19	.30	33.70	23.34	57.04	2.40	2.94	2.5
Sambucus racemosa	1	14.68	.63	19.12	1.80	6.60	21.06	27.66	1.16	3.59	3.0
Prunus virginiana	1	9.23	.40	5.94	.56	12.50	29.64	42.14	1.77	2.73	2.3
Rosa spp.	1	5.41	.23	2.86	.27	18.40	34.48	52.88	2.22	2.72'	2.3
Cornus stolonifera	1	5.82	.24	20.22	1.90	7.50	25.88	33.38	1.40	3.54	3.0
Amelanchier alnifolia	1	3.26	.14	3.44	.32	24.00	43.62	67.62	2.84	3.30	2.[illegible]
Sorbus scopulina	1	5.19	.22	4.03	.38	15.20	49.90	65.10	2.73	3.33	2.8
Symphoricarpos albus	1	4.36	.19	5.59	.53	30.70	28.75	59.45	2.50	3.22	2.7
Actaea rubra	1	11.25	.48	19.32	1.82	5.40	33.11	38.51	1.62	3.92	3.3
Streptopus amplexifolius	1	8.96	.39	3.52	.33	29.50	20.43	49.93	2.10	2.82	2.4
Arctostaphylos uva-ursi	1	2.64	.12	5.41	.51	13.70	38.41	[illegible]2.11	2.19	2.82	2.4
Berberis repens	1	9.20	.40	6.10	.57	21.00	36.40	57.4[illegible]	2.41	3.36	[illegible]
Juniperus horizontalis	1	3.8[illegible]	.16	18.60	1.74	22.00	21.40	43.4[illegible]	1.82	3.72	3.1
Crataegus sp.	1	3.0[illegible]	.13	3.50	.33	11.90	46.40	58.30	2.45	2.91	[illegible]
Lonicera involucrata	1	5.94	.26	2.46	.[illegible]3	40.40	28.17	68.57	2.88	3.37	[illegible]
(Average) berries		(6.46)	(.28)	(6.96)	(.65)	(23.12)	(31.67)	([illegible])	(2.31)	(3.24)	([illegible].7)
Pinus albicaulis (nuts)		14.20	.61	30.45	2.86	-	-	12.45	[illegible]	3.99	3.[illegible]

All results reported on a dry weight basis.

Average caloric values/gram used to obtain total Kcals/gram (Schmidt-Nielsen, Knute, 1975).

Protein = (urea free) 4.3

Ether extract = [illegible].4

Nitrogen-Free Extract = 4.2

ORIGINAL PAGE IS OF POOR QUALITY

in whitebark pine nuts.

Protein levels were highest in *Carex* spp., *Actaea rubra*, the foliage of *Equisetum arvense*, seed pods of *Xerophyllum tenax*, roots of *Claytonia megarhiza*, foliage of *Trifolium repens*, berries of *Sambucus racemosa*, and the nuts of *Pinus albicaulis*. In general, nitrogen-free extract, both sugars and non-sugars, was relatively low in those food plants exhibiting the highest protein content.

Data from samples taken throughout the growing season should, in the future, provide more seasonally representative values for each species. However, the percent of total Kcal/g (Energy Value Percent = EVP) for each plant food or category shown in Table 10 indicates the relative energy values available to the grizzly and is useful for explaining why each species is utilized by the bear.

The caloric values of carbohydrates found in 21 berries were measured (Table 11). Highest sugar values were recorded for *Lonicera involucrata*, *Vaccinium scoparium*, and *V. globulare*; lowest values were from *Crataegus* spp., *Berberis repens*, and *Juniperus horizontalis*. Non-sugar carbohydrates were highest for *Sorbus scopulina*, *Crataegus* spp., *Amelanchier alnifolia*, *Arctostaphylos uva-ursi*, and

Table 11 Caloric values of carbohydrates in 21 berries recorded in the Scapegoat study area.

Bear Food Plants	Carbohydrate Percent		Carbohydrate (Kcals/g)		Total Carbohydrate	
	Sugars	Non-Sugars	Sugars	Non-Sugars	Percent	Kcals/g)
Lonicera involucrata	40.40	28.17	1.70	1.18	68.57	2.88
Vaccinium scoparium	40.00	26.23	1.68	1.10	66.23	2.78
Vaccinium globulare	38.00	27.01	1.60	1.14	65.16	2.74
Shepherdia canadensis	34.00	27.13	1.43	1.14	61.13	3.26
Ribes lacustre	33.70	23.34	1.42	.98	57.04	2.40
Ribes cereum	33.60	32.13	1.41	1.35	65.73	2.76
*Symphoricarpos albus	30.70	28.75	1.29	1.21	59.45	2.50
*Streptopus amplexifolius	29.50	20.43	1.24	.86	49.93	2.10
Fragaria virginiana	25.20	33.32	1.06	1.40	58.52	2.46
*Amelanchier alnifolia	24.00	43.62	1.02	1.82	67.62	2.84
Rubus sp.	22.30	31.06	.94	1.30	53.36	2.24
*Rosa sp.	18.40	34.48	.77	1.45	52.88	2.22
*Sorbus scopulina	15.20	49.90	.64	2.09	65.10	2.73
Arctostaphylos uva-ursi	13.70	38.41	.58	1.61	52.11	2.19
*Prunus virginiana	12.50	29.64	.53	1.24	42.14	1.77
*Cornus stolonifera	7.50	25.88	.32	1.08	33.38	1.40
*Sambucus racemosa	6.60	21.06	.28	.88	27.66	1.16
*Actaea rubra	5.40	33.11	.23	1.39	38.51	1.62
*Juniperus horizontalis	22.00	21.40	.92	.90	43.40	1.82
*Berberis repens	21.00	36.40	.88	1.53	57.40	2.41
*Crataegus sp.	11.90	46.40	.50	1.95	58.30	2.45

*Berries present but not recorded as utilized by grizzlies in the Scapegoat study area. Carbohydrates excludes crude fiber portion.

Berberis repens. However, a high sugar content may influence selection and utilization of a specific food to a greater degree than does actual carbohydrate energy value. The bear's well-known taste for sweets is best satisfied by berries having high sugar content such as *V. scoparium* and *V. globulare*. Certainly, the high IVP (5.4) for these foods suggests that they have a high preference value. *Lonicera involucrata* and *Shepherdia canadensis* also have high sugar values, but do not taste sweet by human standards and may not be so palatable to grizzlies as are *Vaccinium* berries. *Shepherdia* is far less abundant than *Vaccinium* (Tables 3 and 4), possibly a more important factor determining utilization than are sugar content or total energy values.

Energy Values of Food Plants Composing Major Energy Sources

Earlier in the text, we described the abundance, distribution, and utilization of four energy source categories within the alpine and subalpine zones. Measurement of caloric values for individual food plants and average caloric values for food plant groupings showed that pine nuts rated highest with 3.99 Kcal/g, berries second (3.21 avg.), and forbs third (2.81 avg.), with the grasses and sedges having the lowest average of 2.56 Kcal/g (Table 12). Caloric values of the four energy sources were then compared with IVPs, abundance, and seasonal availability of each (Table 13). The two food sources having the highest energy values, pine nuts and berries, are the least available to grizzlies, both seasonally and annually. Those with the lowest energy values, graminales and forbs are, on the other hand, consistently available. Thus, the high importance values (IVP) of grasses and forbs appear to be more closely related to their abundance, seasonal availability, and wide distribution than to their average energy values.

This is substantiated by similar data from Yellowstone. Comparison of the IVPs for the four major food plant groupings in the Scapegoat ecosystem with those measured in the Yellowstone ecosystem (Table 14) showed that the IVP for graminales in Yellowstone was double that for Scapegoat, while the values for forbs were sixfold greater in Scapegoat than in Yellowstone. However, graminales and forbs, both low-calorie food plant groups, when considered together showed almost identical values of 67.3 and 67.1 for Scapegoat and Yellowstone, respectively. The IVPs for the high-calorie groupings, berries and nuts, were also

Table 12.
Average Caloric values for Major Food plant groups (energy sources) in the Alpine and Subalpine Zones of the Scapegoat Study Area.

Food Plant Groups (Energy Sources)

Graminales		Forbs		Berries (Shrubs)		Pine Nuts (Trees)	
Plants	Kcals/g	Plants	Kcals/g	Plants	Kcals/g	Plants	Kcals/g
Cyperaceae	2.30 foliage	Claytonia megarhiza	2.53 foliage & roots	Xerophyllum tenax	3.76 seed pods	Pinus albicaulis	3.99
Gramineae	2.13 foliage	Equisetum arvense	2.58 foliage	Arctostaphylos uva-ursi	2.82 berries		
Melica spectabilis	3.26 bulblets	Lomatium cous	2.59 roots	Ribes lacustre	2.94 berries		
		Claytonia lanceolata	3.94 corms	Vaccinium scoparium	3.52 berries		
		Polygonum bistortoides	2.40 roots	Vaccinium globulare	3.22 berries		
		Erythronium grandiflorum	3.63 bulbs	Vaccinium (Ave.)	(3.37) berries		
		Cirsium scariosum	2.96 roots	Shepherdia canadensis	3.26 berries		
		Hedysarum occidentale	1.98 roots	Fragaria virginiana	2.97 berries		
		Heracleum lanatum	2.53 foliage	Rubus spp.	2.82 berries		
		Xerophyllum tenax	2.27 leaf base	Lonicera involucrata	3.37		
		Perideridia gairdneri	3.61 tubers	Berberis repens	3.38		
		Osmorhiza occidentalis	2.79 roots	Amelanchier alnifolia	3.30		
Average	2.56	Average	2.81	Average	3.21	Average	3.99

Average Kcals/g of all food classes=2.98

Table 13. Average caloric values of energy categories related to their IVP's, food plant abundance values, and seasonal availability in the Grass-shrublands and Coniferous Forest of the alpine and subalpine zones.

Vegetation	Kcals/g (avg.)	Importance Value Percent (avg.)	Food Plant Abundance (avg.)* Grass-Shrublands	Coniferous Forests	Availibility (Mo.)
Graminales	2.56	29.7	34.6		6
Forbs	2.81	37.6	12.2		6
Berries	3.21	12.5		32.9	3
Nuts	3.99	20.4		17.0	4

* Not an average of averages, but computed from plant total coverage values.

Table 14. Comparison of Importance Value Percents for major food plant groups in the Scapegoat Ecosystem to those for the Yellowstone Ecosystem.

Plant Food Group	Scapegoat Importance Value Percents		Yellowstone Importance Value Percents		Avg. Kcal/g
Graminales	29.7	67.3	60.8	67.1	2.56
Forbs	37.6		6.3		2.81
Berries	12.5		12.0		3.21
Nuts	20.4		20.8		3.99

Note: Number of scats analyzed in: Yellowstone = 487 - (Craighead J.J. 1968-1970)
Scapegoat = 282 - (1972-1976)

nearly identical. That the values presented for the two areas (widely separated in time and distance) would so closely match suggests that, in general, the abundant, highly dependable low-calorie food plants represent about 2/3 of the grizzlies' diet, while the less abundant, less dependable high-calorie food plants comprise the other 1/3. Thus, abundance and availability, rather than energy values, would appear to determine the grizzlies' long-term food habits.

An average energy value of 3.0 Kcal/g for plant foods used by grizzlies (Table 12) is low compared to the value of 5.60 Kcal/g recorded by Mealey (1975) for elk meat (Cervus canadensis). The grizzly exhibits a decided preference for animal flesh, but, because for extended periods of time animal protein is not available, the bear has made evolutionary adjustments whereby the species supplements its diet with a wide range of food plants.

High Energy Plants Showing No Observable Use by Grizzlies

In addition to those discussed, some high energy food plants (Table 15) not observed to have been used by grizzlies in the alpine and subalpine zones of the Scapegoat were found to be utilized in the temperate zone of

Table 15 Summary of caloric values of some high energy food plants not recorded as utilized by grizzlies in the alpine and subalpine zones of the Scapegoat study area.

Bear Food Plants	Graminales (roots) Kcal/g	Forbs (foliage & roots) Kcal/g	Shrubs & Trees (fruits & berries) Kcal/g
	FOOD TYPE		
Luzula hitchcockii		2.71	
Trifolium repens		2.80	
Veratrum viride		1.91	
Sambucus racemosa			3.59
Prunus virginiana			2.73
Rosa spp.			2.72
Cornus stolonifera			3.54
Sorbus scopulina			3.33
Symphoricarpos albus			3.22
Actaea rubra			3.92
Streptopus amplexifolius			2.82
Juniperus horizontalis			3.72
Crataegus spp.			2.91
Average Kcal/g Food Class	00	2.47	3.25
Average Kcal/g All Food Classes			3.07

Note: Bear use was observed in the Scapegoat and Danaher study areas of all plants listed above but not in Scapegoat area. Actaea rubra was not utilized in any of the study areas.

Scapegoat and in the Yellowstone area. Thus, it seems probable that Trifolium repens, Sorbus Scopulina, Sambucus racemosa, and Streptopus amplexifolius were used, though not identified in feces or confirmed by direct field observation. Sambucus racemosa and Sorbus scopulina were rarely encountered in the Scapegoat area providing a probable explanation for the lack of observed use.

Prunus virginiana, Rosa spp., Cornus stolonifera, and Symphoricarpos albus were more abundant in the temperate than in the subalpine zone of the Scapegoat area and were utilized there; however, this zone, for reasons stated earlier, was not included in food habits analysis.

The berries of Actaea rubra and Juniperus horizontalis showed higher energy values than did any of the other fruits and seeds, with the single exception of Pinus albicaulis. The berries of A. rubra purportedly contain mild toxins and may not be very palatable to the grizzly; however, because of their high energy content and clumped fruiting arrangements, we would expect to find use of these berries, as well as those of J. horizontalis, with additional food habit sampling.

Of the specific food plants comprizing the major energy source groupings (Table 12), some are more important and, therefore, more critical to the well-being of the grizzly than are others. The need to individually evaluate these is a difficult task because of the great variety of diet items. Also, the utilization of any specific food plant by bears is usually dependent upon the relative temporal and spatial abundance and availability of other food plants as well as upon energy output needed for acquisition relative to energy intake provided.

Energy Considerations

It is obvious to anyone who has picked berries that some species are more easily gathered than are others because of their habit of growth and fruiting arrangements. For instance, *Sambucus racemosa* is characterized by large umbells supporting hundreds of small fruit with each bush having numerous fruiting heads. Fruit from this plant can be gathered far more rapidly than can the berries of *Vaccinium scoparium*. In spite of differences in berry picking technique between bear and man, berries difficult for man to gather are also difficult for the bear. This fact was established by direct observation of radio-instrumented bears in Yellowstone. We concluded that the time required for a man to pick various species of berries was a good indication of the relative time the grizzly would require. Accordingly, we recorded the time required for one man to pick one pint of berries from each of 24 food plants utilized by grizzlies (Table 16). This was done during what we considered to be peak abundance years or at locales where berries of a particular species were very abundant. Peak abundance for each species was estimated from long experience in the field. Over a 7-year period all species evaluated attained high productivity levels at some time. However, picking time for 5 of the 24 species was recorded also during seasons of medium and low berry production. Data for the 24 species of berries were rated and ranked based on the picking time. A rating of 1 corresponds to a picking time of between 1 and 10 minutes; 2, 11-20 minutes; 3, 21-40 minutes; and 4, 41 minutes or longer.

Plants with the highest rating of 1 were those with clumped fruiting arrangements and, with one exception, all were shrubs. Many of those rating 2 were also shrubs with clumped fruits or were forbs with high selected abundance ratings. Those with ratings of 3 or 4 had relatively low abundance ratings and/or solitary or dispersed fruiting arrangements.

For Lonicera involucrata or L. utahensis to be

Table 16. Time required for one man to pick one pint of berries from food plants of importance to grizzly bears.

Food Plant	Picking Time in Minutes			Rating
	High Density	Medium Density	Low Density	
Shepherdia canadensis	10	60	420	1
Sorbus scopulina	5			1
Sambucus racemosa	5			1
Symphoricarpos albus	10			1
Cornus stolonifera	9			1
Actaea rubra	10			1
Prunus virginiana	8			1
Vaccinium globulare	20	90	120	2
Arctostaphylos uva-ursi	15	45	200	2
Ribes cereum	20			2
Amelanchier alnifolia	20			2
Rosa spp.	20			2
Juniperus horizontalis	20			2
Crataegus sp.	12			2
Vaccinium scoparium	30	120	360	3
Fragaria spp.	30	85	340	3
Ribes lacustre	35			3
Rubus spp.	25			3
Berberis repens	40			3
Lonicera involucrata	60			4
Lonicera utahensis	120			4
Streptopus amplexifolius	45			4
Rubus parviflorus	80			4
Clintonia uniflora	190			4

utilized by grizzlies would require such an expenditure of time and energy by the bear that it would appear to be of negative energy value. The same is true for Rubus parviflorus, Clintonia uniflora, and Streptopus amplexifolius. These berries are normally eaten fortuitously and seldom in any quantity. Berries with a 3-rating such as Vaccinium scoparium, Fragaria spp., Ribes lucustre, Rubus spp. (other than R. parviflorus), and Berberis repens appear to be rewarding for the bear only at specific locales of high abundance. Vaccinium scoparium is intensively used as is indicated by the high preference value (73.8 for V. scoparium and V. globulare combined), thus, the bear feeds on it though much time is needed to accumulate a full meal. The same may be true for Fragaria and the other 3-rated berries, as well. A grizzly can easily make a meal (a quart or more) on the 1- and 2- rated berries during periods of high productivity or on sites of unusually high abundance. However, it would appear to be quite difficult for the bear to feed efficiently on the 1-2 rated Vaccinium globulare, Shepherdia canadensis, and Arctostaphylos uva-ursi during seasons of low production or in locales where the berry crops are of low, or even medium, abundance. The relationship between energy output and energy intake would seem to govern, to some degree, what berries the grizzly utilizes at any given time or place. More quantitative and precise data is needed before the picking time ratings for specific berries can be directly compared with their IVPs, PVPs, or EVPs.

Evaluation Criteria for Specific Food Plants and Food Plant Categories

The extremely wide range of plant species eaten by grizzlies (Section I) and the varied portions consumed require an evaluation based on a multiplicity of criteria. As we have shown, IVPs alone are not sufficient, nor are the abundance, distribution, and caloric values. To define criteria and provide practical values for rating the importance of a food plant, we established five major descriptive categories, as follows:

1. Food habits evidence-consisting of Importance Value Percent and average volume per diet item (the latter is an expression of preference); direct observation and indirect evidence of bear feeding activity.

2. Food plant abundance-determined from random and selected sampling.

3. Random distribution of food plants.

4. Temporal and spatial plant availability-determined by zonal distribution, seasonal growth and development and annual fluctuations in seed production.

5. Energy values-expressed as caloric values, (Kcal/g).

To describe each food plant and plant category in terms of the evaluation criteria it will be necessary to repeat in a different format some of the information presented earlier. Because it is the individual food plants within a land unit, a vegetation type, or a climatic zone that largely determine whether habitat is important, or in some instances critical, to the grizzly, we believe that an integrated evaluation index defining the relative role of each species is imperative. To accomplish this, food plant abundance and occurrence values were calculated for the entire study area (Table 17). This was done by dividing the total percent abundance of the species by the total percent abundance of all vegetation sampled in the study area. This is expressed in Table 17 as percent abundance to total vegetation. To arrive at the percent abundance of food plants only, the total percent abundance of the species was divided by the total percent cover of all bear food plants. Finally the percent occurrence of the food plants to total vegetation was calculated by dividing the total number of occurrences of the species per sample plot by the total number of plots (460) in the study area. These values were then compared with other parameters shown in Table 18.

Table 17: Summary of percent abundance and occurrence of grizzly bear food plants in the Scapegoat Study Area (460 plots).

Bear Food Plants	Percent Abundance To-Total Vegetation	Percent Abundance Food Plants Only	Percent Occurrence To-Total Vegetation
Graminales			
Carex spp.	12.3	20.9	46.7
Festuca idahoensis	7.0	12.0	21.3
Gramineae	2.5	4.3	14.3
Calamagrostis rubescens	3.1	5.3	8.3
Festuca scabrella	2.0	3.3	4.3
Agropyron spicatum	.6	1.1	2.5
Calamagrostis canadensis	.6	1.0	1.1
Phleum pratense	.4	.7	1.1
Bromus sp.	.1	.2	.4
Deschampsia cespitosa	.1	.2	.4
Poa pratensis	.1	.1	.4
Danthonia unispicata	T	.1	.4
Poa spp.	T	T	.2
Phleum alpinum	T	T	.2
Melica spectabilis	T	T	.2
Subtotal	28.8	49.2	
Forbs and Shrubs			
Vaccinium scoparium	11.2	19.1	28.3
Xerophyllum tenax	9.8	16.7	28.3
Arctostaphylos uva-ursi	1.6	2.7	5.4
Vaccinium globulare	1.5	2.6	6.5
Fragaria virginiana	.8	1.4	7.0
Shepherdia canadensis	.8	1.3	5.7
Erythronium grandiflorum	.5	.9	2.6
Juncus parryi	.5	1.3	2.2
Hedysarum spp. & o.	.5	.8	5.2
Polygonum spp.	.4	.6	1.3
Lomatium spp.	.3	.6	4.1
Heracleum lanatum	.3	.5	2.2
Equisetum arvense	.3	.5	.9
Claytonia lanceolata	.2	.4	1.1
Ozmorhiza occidentalis	.2	.4	.9
Amelanchier alnifolia	.2	.3	1.3
Symphoricarpos albus	.1	.2	.9
Claytonia megarhiza	.1	.1	.7
Lomatium dissectum	.1	.1	.4
Cirsium scariosum	T	.1	.4
Ribes lacustre	T	.1	.4
Rubus parviflorus	T	.1	.7
Vaccinium myrtillus	T	T	.4
Lonicera utahensis	T	T	.2
Lonicera involucrata	T	T	.2
Hieracium gracile	T	T	.2
Prunus virginiana	T	T	.2
Perideridia gairdneri	T	T	.2
Berberis repens	T	T	.2
Rosa spp.	T	T	.2
Trifolium spp.	T	T	.2
Hedysarum sulphurescens	T	T	.2
Subtotal	29.4	50.8	
Total Bear Food Plants	58.7		
Total Non-Food Plants	41.3		
Total	100.0	100.0	

Finally those parameters that were strictly comparable were incorporated into Table 19 and used to derive a food plant value (FPV) or a value index for each food plant.

The techniques employed in deriving the food plant and behavioral parameters have been stated earlier. The data for direct and indirect observations (Table 18) either reinforce the specific IVP and PVP values, or for some plants, are the sole evidence of utilization since those plants were not recorded in scats. Two direct observations of grizzlies feeding on Lomatium cous and the detection of 102 digging sites indicate heavy use of this plant by grizzlies. Similarly, 15 separate observations of grizzly bears feeding on Claytonia megarhiza and the detection of 17 digging areas strongly supports the IVP and PVP for this plant. On the other hand, single observations of bears feeding on Berberis repens and Ribes lacustre show that these serve as food plants, but that the degree of utilization cannot be quantitatively expressed.

The random abundance and distribution values shown in Table 18 express the percent cover and percent occurrence of a food plant species throughout the entire study area. Thus, the values, 1.6 and 5.4, for Arctostaphylos

Table 18. Relation of grizzly bear feeding habits to food plant parameters in the Scapegoat Study Area.

Food Plants	Feeding Habit Parameters: Scat Analysis: Importance Value Percent (IVP)	Feeding Habit Parameters: Scat Analysis: Preference Value Percent (PVP)	Feeding Habit Parameters: Observation: Number Direct Feeding	Feeding Habit Parameters: Observation: (1,2,3,4) Indirect Feeding	Food Plant Parameters: Random Abundance Values (% Cover)	Food Plant Parameters: Selected Abundance Values (% Cover)	Food Plant Parameters: Random Distribution Value (% Occurrence)	Temporal and Spacial Availability: Climatic Zones	Temporal and Spacial Availability: Seasonal Use	Temporal and Spacial Availability: Seasonal Availability	Temporal and Spacial Availability: Energy Value % (EVP)
Berries and Nuts											
Vaccinium spp.	5.4	18.7	2	6 (3)	12.8	68.0	29.1	A,S,T	3	3	2.8
Shepherdia canadensis	3.5	10.4	-	5 (3)	.8	26.7	5.2	S,T	2	2	2.7
Fragaria virginiana	2.0	2.6	1	1 (3)	.3	15.0	7.0	A,S,T	2	2	2.5
Arctostaphylos uva-ursi	1.6	2.1	-	3 (3)	1.6	51 0	5.4	A,S,T	6	6	2.4
Pinus albicaulis	20.4	17.6	-	6 (4)	7.9	91.0	42 3*	S	4	4	3.3
Forbs											
Claytonia megarhiza	5.5	5.7	15	17 (1)	.1	41 4	7	A	2	2	2.1
Lomatium cous	5.3	12.8	2	102 (1)	.3	41.3	4.1	A,S,T	2	4	2.2
Equisetum arvense	2.3	.9	-	1 (2)	.3	52.0	.9	S,T	3	4	2.2
Claytonia lanceolata	1.2	2.1	-	2 (1)	.2	18.5	1.1	A,S,T	3	4	3.3
Polygonum spp.	.9	2.0	-	1 (1)	.4	10.0	4.3	A,S,T	1	3	2 0
Erythronium grandiflorum	.5	2.1	-	-	.5	15 0	2.6	A,S,T	3	4	3.0
Heracleum lanatum	.1	---	-	2 (2)	.3	25.0	2.2	A,S,T	3	5	2.1
Cirsium scariosum	.1	---	1	1 (2)	T	5.0	.4	A,S,T	2	4	2.5
Hedysarum spp.	.1	---	-	2 (2)	.5	15.0	5.2	A,S,T	2	3	1.7
Graminales											
Gramineae	25.9	7.0	5	5 (2)	16.6	66 5	41.1	A,S,T	6	6	1.8
Cyperaceae	3.8	4.6	3	7 (2)	12.3	43 0	46.1	A,S,T	6	6	1.9

Pinus albicaulis occurred in 88% of the Subalpine forest plots. These plots were used to calculate the occurrence of *P. albicaulis* in the entire forest of the study area.

Notes: Indirect Feeding: (1) = digging evidence, (2) = grazing evidence, (3) = berry stripping. A = Alpine Zone, Sa = Subalpine Zone, (T) = Temperate Zone - Plant also occurs in Temperate Zone but abundance and distribution not recorded in this table. Random Values - taken from all random samples (Section I).
Select Values - taken only from high density sites. ob. = Direct and indirect evidence of use but not represented in scats. Seasonal use = Average period of use Ave. Vol. per Diet Item = Total volume of diet item - its frequency of occurrence in feces.

uva-ursi are its abundance and distribution values, respectively, in relation to all other ground vegetation sampled.

Occurrence by climatic zone is considered in the evaluation process because, in general, plants occurring in two or more zones are more available to grizzlies than those occuring in only one. This is certainly true spatially and, perhaps, temporally as well. Seasonal use is defined to be the number of months a plant was observed to be utilized based on scat analysis and field observation, while seasonal availability concerns the period of time in months a plant remained green and succulent. Months were used as the time unit because a finer unit could not be consistently applied to all species.

Random abundance value is the percentage that any given food plant comprized of the total percent of ground cover sampled in the entire study area. Thus Vaccinium spp. represents 12.8% of the ground vegetation and Shepherdia canadensis, 0.8% with a total of 55.4% for all the food plants listed in Table 19. About 3.3% of the food plants (those lacking IVPs or PVPs) are not represented in Table 19. It has been shown that abundance is an important factor determining utilization of food plants;

Table 19. Calculation of Major Bear Food Plant Values in the Scapegoat Study Area.

	Importance Value % (IVP)	Preference Value % (PVP)	Random Abundance Value %	Climatic Zone Occurrence	Energy Value % (EVP)	Food Plant Value % (FPV)
Berries						
Vaccinium spp.	5.4	18.7	12.8	3.0	2.8	42.7
Shepherdia canadensis	3.5	10.4	.8	2.0	2.7	19.4
Fragaria virginiana	2.0	2.6	.8	3.0	2.5	10.9
Arctostaphylos uva-ursi	1.6	2.1	1.6	3.0	2.4	10.7
Plant Group	12.5	33.8	16.0	11.0	10.4	83.7
Mean Values	3.1	8.5	4.0	2.8	2.6	20.9
Nuts						
Pinus albicaulis	20.4	17.6	7.9	1.0	3.3	50.2
Berries and Nuts Combined						
Plant Group	32.9	51.4	23.9	12.0	13.7	133.9
Mean Values	6.9	10.3	4.8	2.4	2.7	26.8
Forbs						
Claytonia megarhiza	5.5	5.7	.1	1.0	2.1	14.4
Lomatium cous	5.3	12.8	.3	2.0	2.2	22.0
Equisetum arvense	2.3	.9	.3	3.0	2.2	8.7
Claytonia lanceolata	1.2	2.1	.2	2.0	3.3	8.8
Polygonum spp.	.9	2.0	.4	2.0	2.0	7.3
Erythronium grandiflorum	.5	2.1	.5	3.0	3.0	9.1
Heracleum lanatum	.1	---	.3	3.0	2.1	5.5
Cirsium scariosum	.1	---	T	3.0	2.5	5.6
Hedysarum spp.	.1	---	.5	2.0	1.7	4.3
Plant Group	16.0	25.6	2.6	21.0	21.1	86.3
Mean Values	1.8	2.9	0.3	2.3	2.	9.6
Graminale..						
Gramineae	25.9	7.0	16.6	3.0	1.8	54.3
Cyperaceae	3.8	4.6	12.3	3.0	1.9	25.6
Plant Group	29.7	11.6	28.9	6.0	3.7	79.9
Mean Values	14.9	5.8	14.5	3.0	1.9	40.0
Sum of Food Plant Parameters	78.6	88.6	55.4	39.0	38.5	300.1

*Food habit value index for study area

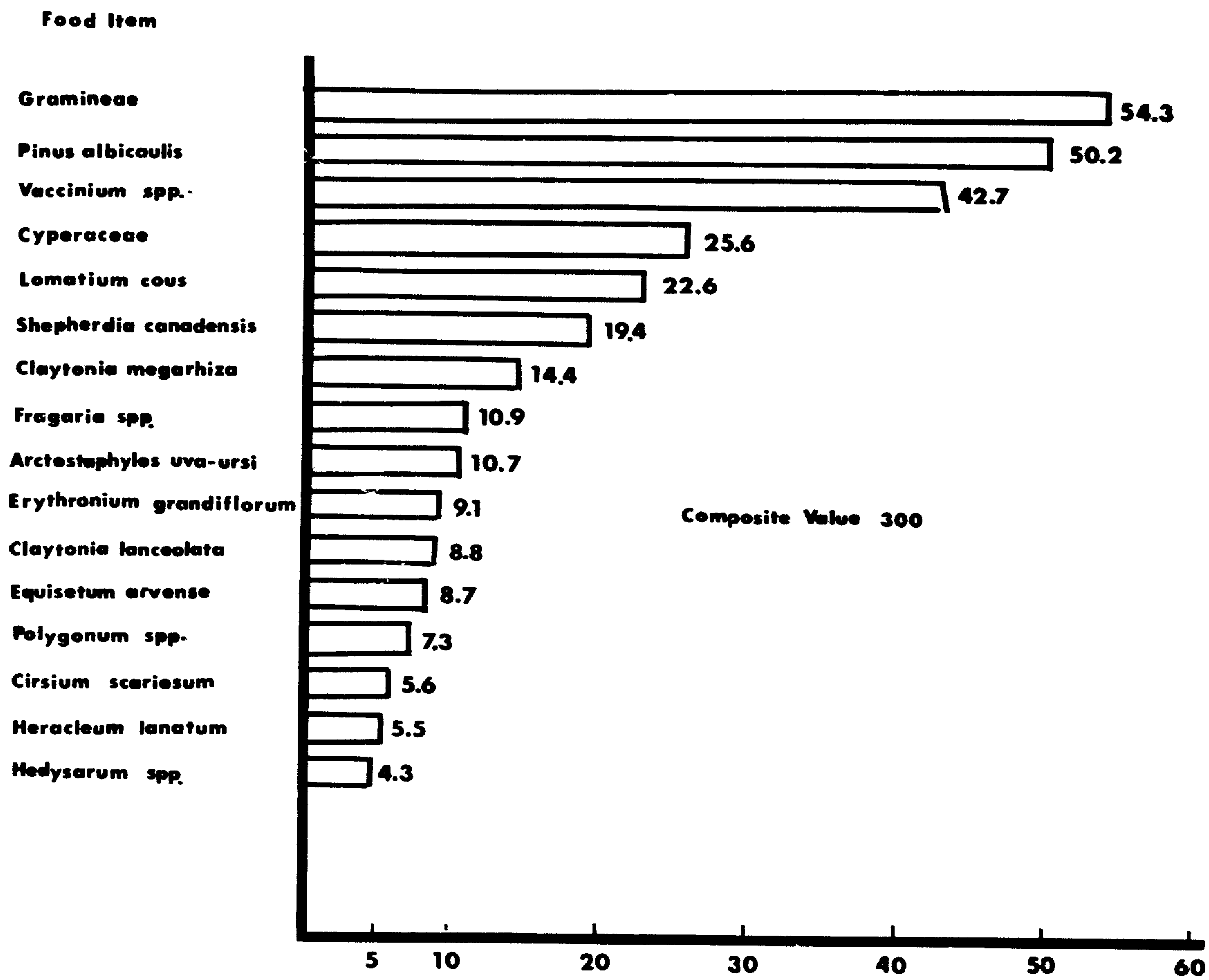
**Food plant value index = sum of plant group Food Plant Values (exceeding the combined group) therefore, a high or low value for this parameter is reflected in the FPV percent for any given food plant. The same is true of the other four parameters discussed earlier in the text.

Occurrence within climatic zones is indicated by a value of 1, 2, or 3. Those plants occurring in only one zone received a value of 1, those in two zones, a 2, and three zones, a 3. Thus, the greater the distribution, the more important the plant to the grizzly bear, and the higher the value between 1 and 3 assigned. Berries were considered as available only when ripe, and tubers for as long as the foliage remained green.

Values for specific food plants may be read from left to right in Table 18; the higher the values for each parameter, the more important is the plant to grizzlies.

We considered it important to synthesize a composite value for each major food plant listed in Table 18 so that these plants could be more easily compared. To accomplish this we selected five distinct values that were strictly comparable for each plant and from these developed composite food plant value percents or value indices.

Fig. 5 Food plant value percents (FPV) for 16 food items utilized by grizzly bears. The value for each plant or plant group is the sum of five food plant parameters found to be important in determining use. The higher the value, the more important the food item is to grizzly bears in the Scapegoat study area.


Food Item
Gramineae
Pinus albicaulis
Vaccinium spp.
Cyperaceae
Lomatium cous
Shepherdia canadensis
Claytonia megarhiza
Fragaria spp.
Arctostaphyles uva-ursi
Erythronium grandiflorum
Claytonia lanceolata
Equisetum arvense
Polygonum spp.
Cirsium scariosum
Heracleum lanatum
Hedysarum spp.
54.3
50.2
42.7
25.6
22.6
19.4
14.4
10.9
10.7
9.1
8.8
8.7
7.3
5.6
5.5
4.3
Composite Value 300
5
10
20
30
40
50
60

Food Plant Value Percents

These food plant value percents (FPVs) for the major food plants of the entire study area and for the four major energy source categories are shown in Table 19. These are food plant value indices and they were obtained for the study area by summing the five parameter values, viz., IVP, PVP, EVP, Food Plant Random Abundance, and Climatic Zone Occurrence. The percentage values shown in each column of Table 19 are comparable for each food plant listed and, therefore, the sums representing a food plant value percent for each plant are also comparable. The higher the FPV, the more important the plant as a food item for grizzlies in the Scapegoat study area.

Gramineae as a group had the highest FPV index (54.3), *P. albicaulis*, second (50.2), with *Vaccinium* spp. third (42.7). The relative FPVs of the various food plants are shown in Fig. 5. Based on the parameters presented in Table 19, the food plant ratings are: Gramineae, 1; *Pinus albicaulis*, 2; *Vaccinium* spp., 3; Cyperaceae, 4; *Lomatium cous*, 5; *Shepherdia canadensis*, 6; *Claytonia megarhiza*, 7; *Fragaria* spp., 8; *Arctostaphylos uva-ursi*, 9; and others descending in value, as illustrated.

A composite food plant value index of 300 was calculated for the entire study area. This value has significance for comparing other areas of grizzly bear habitat where comparable data have been or will be collected in the future. For example, similar indices for representative areas of the Yellowstone ecosystem, the northern Bob Marshall wilderness, the Mission Mountains, Montana, or the North Slope of the Brooks Range, Alaska, could all be compared with Scapegoat and with one another. In the case of suitable but unoccupied habitat, or habitat where the viability of a grizzly bear population is in question (Selway-Bitteroot Wilderness of Montana and Idaho or the San Juan Wilderness of Colorado), then the potential food plant values developed in Section I could be compared with similarly computed values for the area in question. The comparisons could be carried further by looking at such parameters as population size or density, reproductive rates and sow-cub ratios. We should expect to find higher reproductive rates, for instance, associated with areas having the highest composite food plant indices whether actual or potential.

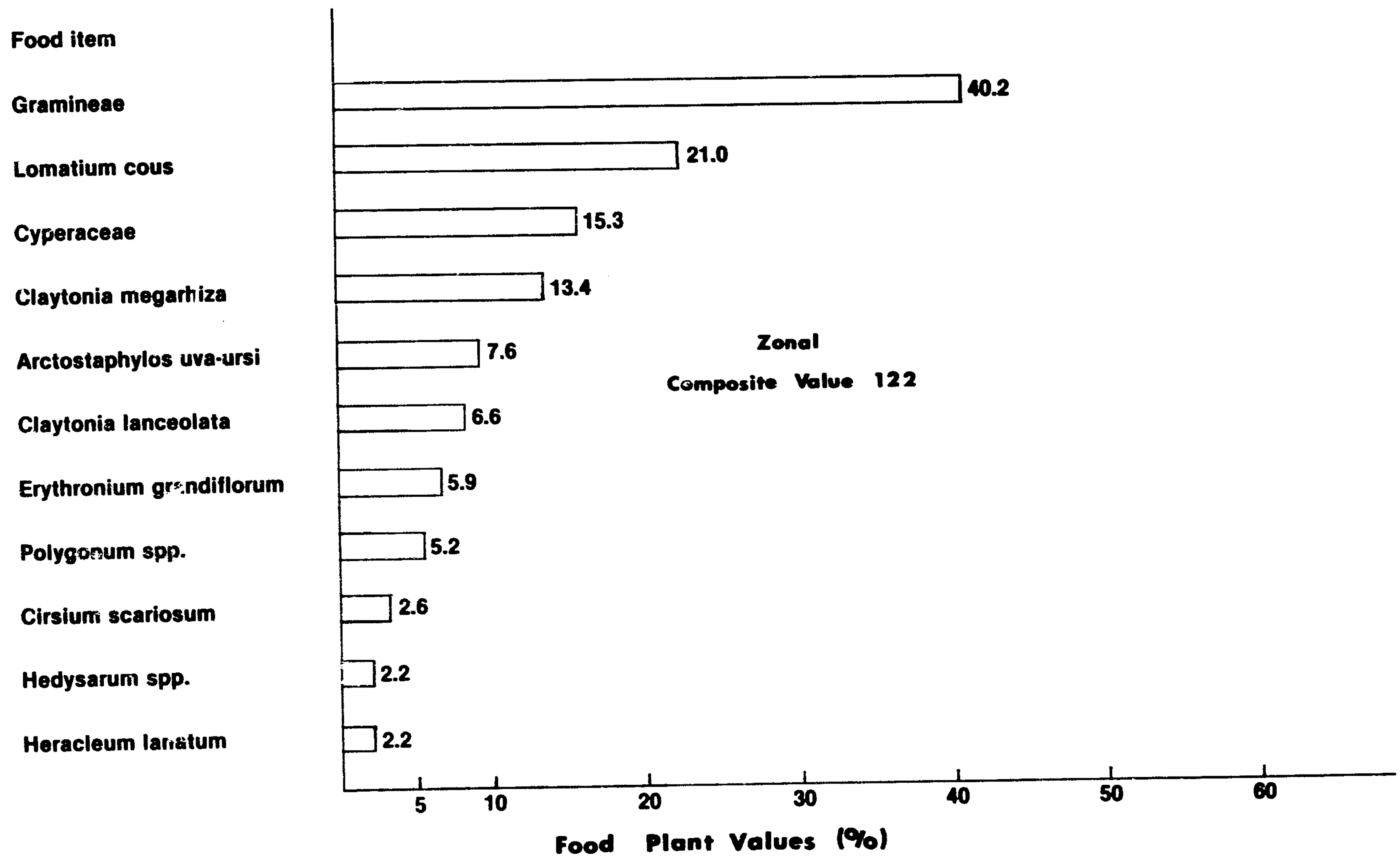
Composite Food Plant Value Percents for the Alpine and Subalpine Zones

Individual food plant values as they relate to the alpine and subalpine zones, respectively, were calculated and are shown in Figs. 6 and 7. A composite food plant value percent was then calculated for the alpine and the subalpine zones. A similar value could not be computed for the temperate zone because of reasons stated earlier in the text. The zonal composite food plant value was derived by summing the Food Plant Values (IVP, PVP, EVP, and Random Abundance Values) for the major food plants of each zone (Tables 1 and 2, Appendix). Thus, the composite values for the alpine and subalpine zones were 122 and 220, respectively, Figs. 6 and 7. The greater diversity of major food plants occurring in the subalpine zone largely accounts for the zone's higher composite food plant value. Species of *Vaccinium* and *Fragaria virginiana* were omitted from the calculations for the alpine zone because at high elevations they seldom produce fruit abundantly and therefore were not considered to be major food plants of the zone.

Zonal Food Plant and Habitat Indices

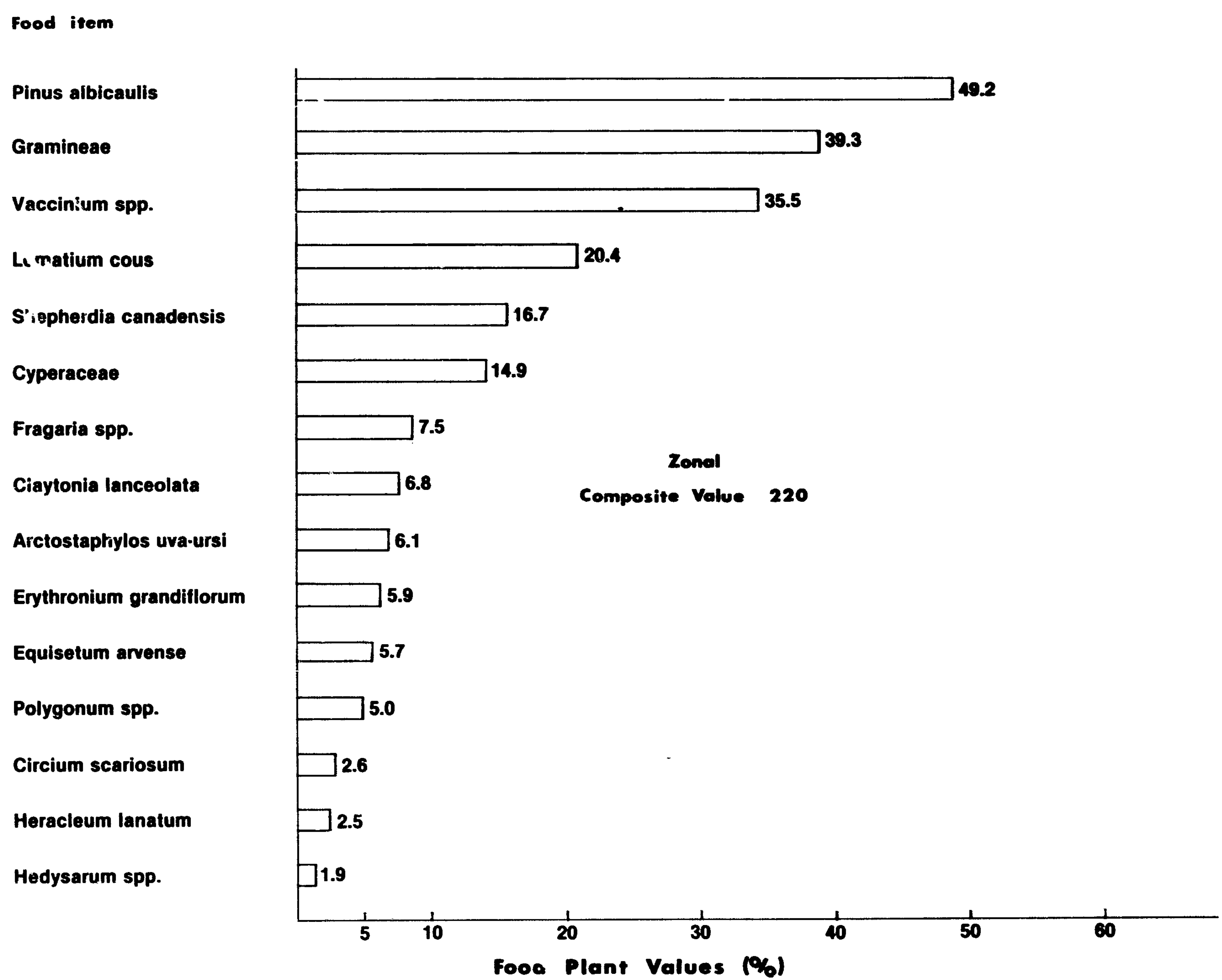
A zonal food plant index for the alpine and for the subalpine zones was obtained by dividing the composite food plant value of each zone by 100. These values with

Fig. 6 Food Plant Value percents for the alpine zone.


Food item
Gramineae
Lomatium cous
Cyperaceae
Claytonia megarhiza
Arctostaphylos uva-ursi
Claytonia lanceolata
Erythronium grandiflorum
Polygonum spp.
Cirsium scariosum
Hedysarum spp.
Heracleum lanatum
40.2
21.0
15.3
13.4
7.6
6.6
5.9
5.2
2.6
2.2
2.2
Zonal
Composite Value 122
5
10
20
30
40
50
60
Food Plant Values (%)

76

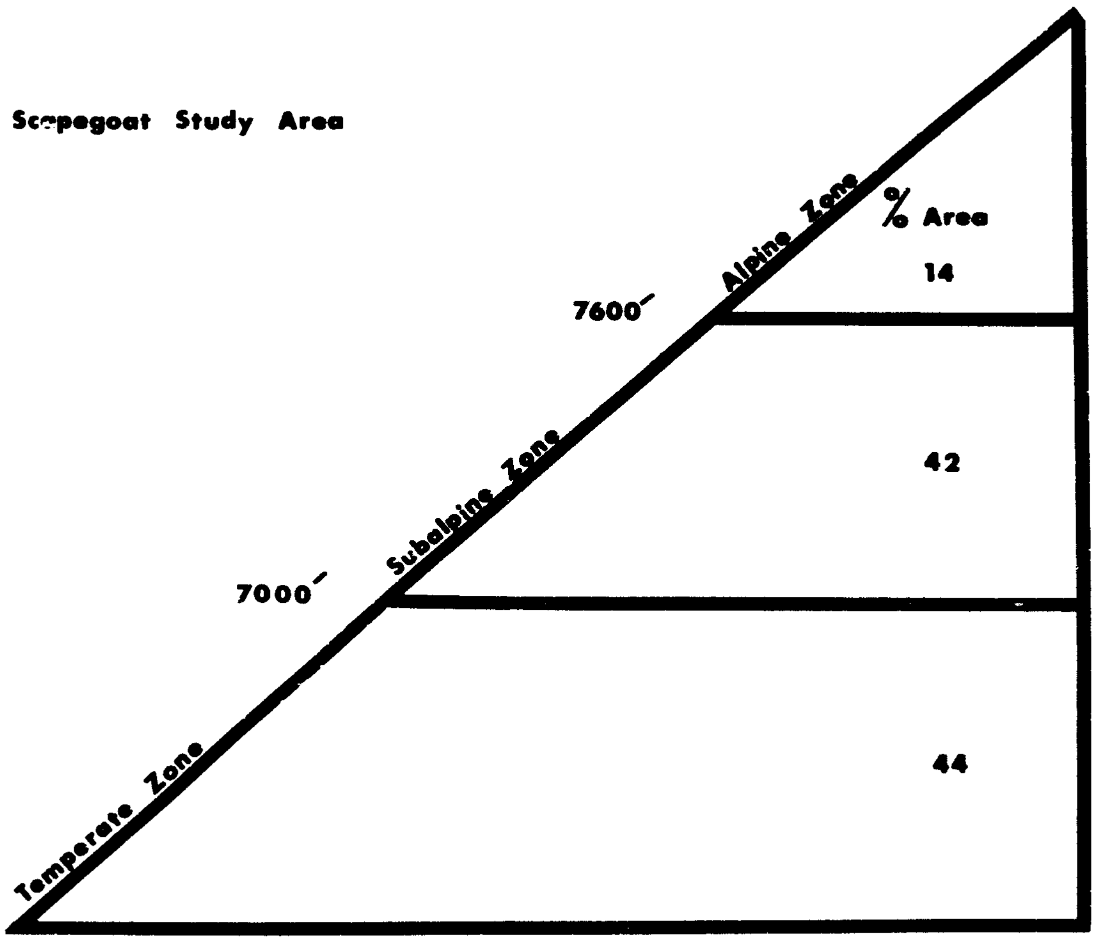
Fig. 7 Food Plant Value percents for the subalpine zone.


Food item
Pinus albicaulis
49.2
Gramineae
39.3
Vaccinium spp.
35.5
Lomatium cous
20.4
Shepherdia canadensis
16.7
Cyperaceae
14.9
Fragaria spp.
7.5
Claytonia lanceolata
6.8
Arctostaphylos uva-ursi
6.1
Erythronium grandiflorum
5.9
Equisetum arvense
5.7
Polygonum spp.
5.0
Circium scariosum
2.6
Heracleum lanatum
2.5
Hedysarum spp.
1.9
Zonal
Composite Value 220
5
10
20
30
40
50
60
Food Plant Values (%)

their corresponding energy source values (Sec. I) were rounded to whole numbers and then combined to form a Climatic Zone Habitat Index (Fig. 8). This index represents the sum of the potential food plant value plus the composite value of the major food plants utilized by grizzlies (as determined from IVP, PVP, EVP, and Random Abundance Values). Thus, an index of 9 for the alpine zone and 33 for the subalpine clearly reflect the difference in grizzly bear plant food resources of the two zones. Essentially they represent for each zone the food potential available, the plant species most commonly utilized, and the size of the land area over which the food plant resource was distributed. The great difference in the climatic zone habitat indices for the two zones is due primarily to differences in food plant diversity, food plant abundance, and size of the areas involved. We can conclude that the plant energy resource of the subalpine zone is 3 to 4 times as great as the alpine zone and thus is more critical to the welfare and survival of the grizzly bear. Because comparable data is not available for the temperate zone, (scats were not collected and analyzed specifically for this zone) we can not develop a zonal habitat index. However, we can make a judgement

Fig. 8 Climatic zone food plant values and habitat rating indices.

Scapegoat Study Area



Energy Source Value		Composite Zonal Food Plant Index		Climatic Zone Habitat Index
8	+	1	=	9
31	+	2	=	33
30	+	—	=	30+

from the potential food plant abundance percentage (Table 24, Section I) and from the diversity of the food plants present in the zone (Tables 20 and 21, Section I). The temperate zone would have a climatic zone habitat index in excess of 30 and therefore comparable to that for the subalpine zone (Fig. 8). Our analysis of the major food plants utilized by grizzly bears further supports a conclusion reached in Section I, that all three climatic zones are essential to the welfare of the grizzly. If the grizzly were to be partially or fully denied the use of any one of the three zones because of competing land uses, a grizzly bear population would be hard put to survive.

How and when the energy sources of each zone are utilized by grizzlies is, of course, a factor not yet considered. Also, other food plant parameters such as distribution, selected abundance, seasonal use, and seasonal availability (Table 18) are very important in determining the usage of various food plants by grizzlies. However, these parameters could not be comparably quantified for each plant or for each zone and thus could not be used in developing the specific food plant values or the climatic zone habitat indices. They are, nevertheless, important parameters and will be considered in a specific evaluation of each major food plant. This plant by plant evaluation follows.

Summary Evaluation of Specific Food Plants and Food Plant Categories

Gramineae

It has been shown that grasses, with an IVP of 25.9 (Table 19), are an important energy source for grizzlies. Both their abundance and distribution values exceed those of other food plant categories. The low preference and energy values (Fig. 5 and Table 19) suggest that grasses may be utilized heavily because they are abundant and available rather than because they are preferred over other plant foods. Nevertheless, their FPV was 54.3 and their overall index rating number one (Table 19).

The grasses occur in all three climatic zones and are seasonally available to grizzlies in the alpine and subalpine zones for approximately 5 months (May through October). In the temperate zone, early emerging species are available from April to November. Grizzlies continue to use this food source in all zones (especially in mesic and hydric sites) throughout the forage year. Grasses were found in the feces for every month that the bears were out of winter dens and foraging.

Utilization of grasses may be overemphasized in the fecal analysis (IVP) because of the durability factor discussed earlier. Also, individual species were not isolated and identified. Nevertheless, grasses must be considered one of the staple food categories. Our data showed an IVP of 60.8 for grasses and sedges combined in the Yellowstone area ecosystem and Mealey (1975) concluded that grasses were one of the more important food items there. In the Scapegoat area they sustain bears during periods when more highly preferred and more nutritious foods are either not abundant or not available. They were frequently consumed along with other diet items; however, when pine nuts and berries were abundant, these higher preference foods were often consumed to the exclusion of grasses as well as other available plant foods.

Cyperaceae

The random and selected abundance values (12.3 - 43.0%) for sedges are comparable to those for the grasses (Table 18). However, the IVP of 3.8 for sedges (Table 19) is extremely low compared to those for the grass and forb categories (25.9 and 16.0, respectively). The IVP showed no positive correlation with either the abundance or the distribution values. Like the grasses, sedges are found in all three climatic zones and are seasonally available to bears for the entire foraging period.

Grizzlies fed on sedge shoots as soon as the snow receded, utilizing them to some extent during the entire foraging year and at all elevations. Use of *Carex geyeri* (Fig. 9) was observed in the spring. Other species were utilized, but could not be specifically identified. The average caloric value for emergent and for mature sedges (*Carex* spp.) was 2.30 Kcal /gram (Table 10). Emerging sedge shoots showed a higher value (2.43 Kcals/g). The maturing plants of most species of sedge rapidly lose their succulence and are then less palatable and less nutritious. Sedges with an FPV of 25.6 ranked fourth as a food category (Table 19) and they are a reliable energy source providing nutrients when more highly preferred foods are scarce or unavailable. Their absence in the fall diet of the grizzly (Table 9) indicates they received more restricted use than did the grasses which were intensively utilized during both the spring and summer months.

Forbs

A large number of individual forbs, that occurred

Fig. 9 Elk sedge (*Carex geyeri*). This abundant and widely distributed sedge is among those eaten by grizzlies.

infrequently, and generally in small volume in the bear scats, were lumped as unidentified items. These had a combined IVP of 20.9 (Table 13). Identifiable forbs showed a combined value of 16.7; thus forbs as a group (those identified to species and those not) had an IVP of 37.6, exceeding the values for either grasses or pine nuts (Table 13). Forbs showed random and selected abundance values comparable to those for grasses and sedges and had an average caloric value of 2.81 Kcal/g (Table 10). They were an important energy source during all seasons and in all three climatic zones. Some species were highly preferred foods (Table 17) while others appeared to be taken incidentally.

Claytonia megarhiza

Claytonia megarhiza (Fig. 10), found only in the alpine zone, had very low random abundance and distribution values of .3 and 1.9, respectively; nevertheless had the exceptionally high IVP of 5.5 (Table 5). In spite of its extremely limited distribution it rated seventh as a food plant in the study area with a FPV of 14.4 (Table 19). and an energy value of 2.53 Kcal/g (Table 10). Limited to rock talus at elevations above 8,500 feet, this plant

Fig. 10 Photographs showing *Claytonia megarhiza*: above, growing in rock slides at 8,500 feet; below, starchy roots as they appear after extraction from the rock talus.

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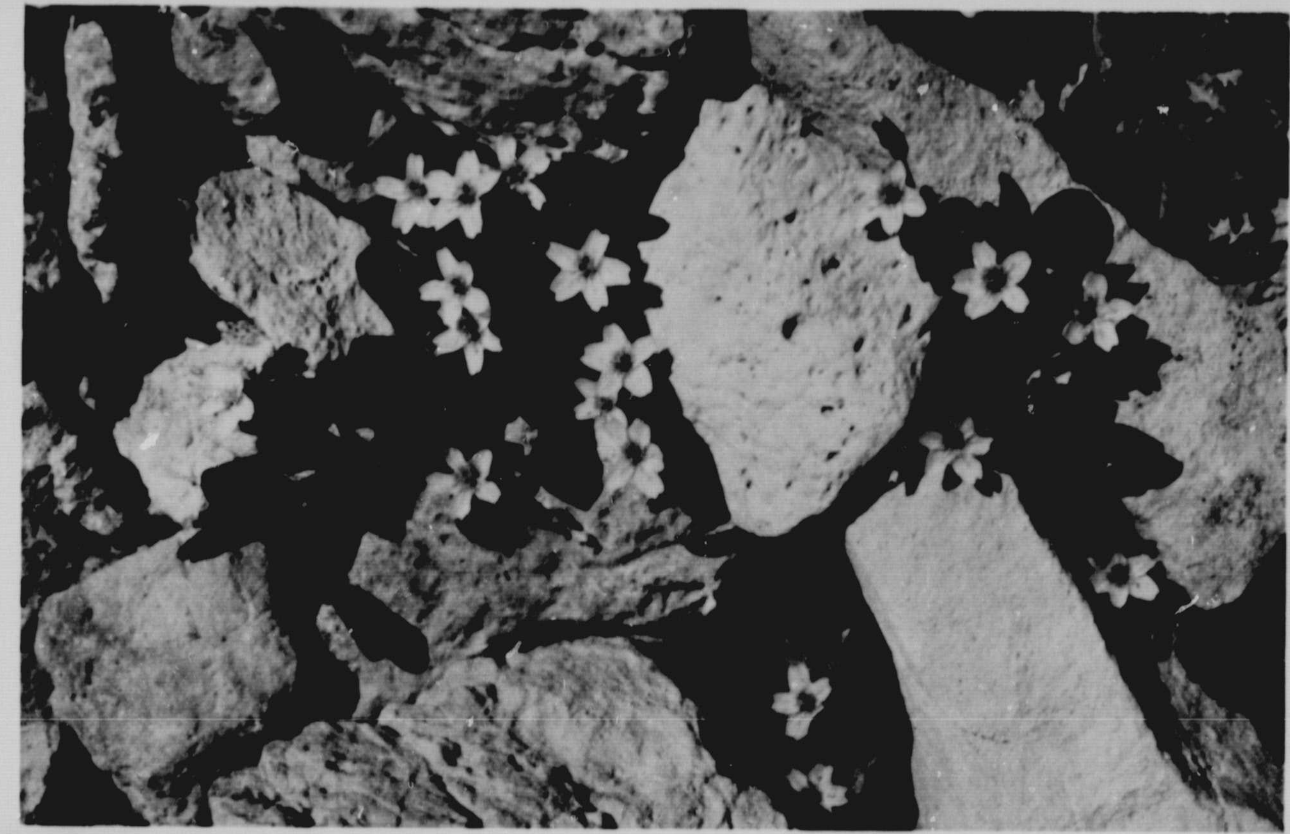


exhibited a highly sporadic distribution. Even on the high rock talus it occurred on some slopes but was completely absent on others. At selected sites it represented a high percentage of the vegetation present as indicated by a selected abundance value of 41.4% (Table 18). Grizzlies showed a decided preference for it, normally feeding on it during July and August. In years of light snow pack it becomes available in late June. It can be considered among the more important foods found in the alpine zone in spite of its low random abundance value and very limited distribution (Table 18). Individual grizzlies located this plant within their home ranges, fed at high density sites, and learned to return to these year after year. Fifteen separate observations, over a three year period, were recorded of at least 6 individual grizzlies feeding on the leaves, stems and the starchy roots of this spring beauty. When they fed on C. megarhiza the bears turned over rocks to get the plants which were secluded in rocky crevices. At times they disturbed acres of rock talus. Seventeen such areas were recorded varying in size from .5 to 10 acres. These "digging" areas (where approximately 70 percent of the rock talus had been disturbed by grizzlies) encompassed 19.5 acres. Normally, feces were found in the immediate vicinity of the larger feeding siter and frequently bears bedded down below the talus slopes where they fed.

A moth belonging to the family Noctuidae (Fig. 11) "overwinters" in the rock slides where C. megarhiza is found. This moth is also a highly preferred food. Both diet items were consumed simultaneously, making it difficult to evaluate the relative importance of each item. Our observations indicate that grizzlies selectively seek both the moth and C. megarhiza. The extremely limited distribution of the moth indicates that grizzlies exhibit a high preference for this type of protein and learn to utilize it as well as C. megarhiza by specific locale and and season. This type of feeding behavior, to satisfy specific hunger drives at localized sites, is common. It appears to be learned behavior that is reinforced by repetitive visits over a period of time. In Yellowstone, we learned from observing radio-instrumented grizzlies that they located and annually utilized local concentrations of Melica spectabilis and Perideridia gairdneri, both high nutrient foods (see Table 10). Specific locales were frequented for several weeks by identifiable bears.

Equisetum arvense

Equisetum arvense (Fig. 12) with a FPV of 8.7 (Table 19) was utilized especially during the early growth period.

98

Fig. 11 Moths of the family Noctuidae inhabit rock slides at elevations above 8,500 feet. At certain sites they number in the tens of thousands, serving as food for numerous birds and mammals including the grizzly bear.

9+

Fig. 12 Photographs showing two common grizzly bear food plants: Heracleum lanatum (left); Equisetum arvense (right).

Available by mid-May in the temperate zone, its low random abundance value (.3%) and relatively high IVP (2.3) suggests that this plant was eaten primarily at hydric sites where it grows profusely (Table 18). Its random abundance values in the Grass-Shrublands of the subalpine zone were 1.2 and 0.3% throughout the entire study area, respectively (Tables 3 and 18). In seepage areas and riparian habitats E. arvense occurred in dense mat-like growths where its selected abundance value was 52.0% (Table 18). It was also abundant in the Abies lasiocarpa/Calamagrostis canadensis forest habitat type. Where mat-like growth of this plant occurs, grizzlies can graze large quantities rapidly and with little expenditure of energy. Equisetums have an extremely wide distribution both altitudinally and latitudinally. Like the graminales they provide a staple food supply.

Lomatium cous

All species of Lomatium found in the alpine, subalpine and temperate zones were utilized by grizzlies. L. cous (Fig. 13), most abundant in the alpine and subalpine zones, had a FPV of 22.6; ranking fifth as a plant food for grizzlies (Table 19). Like Claytonia megarhiza,

Fig. 13 Photographs showing Lomatium cous: above, growing in shallow limestone soil at an elevation of about 8,000 feet; below, the long tapered roots and flowering stalk.

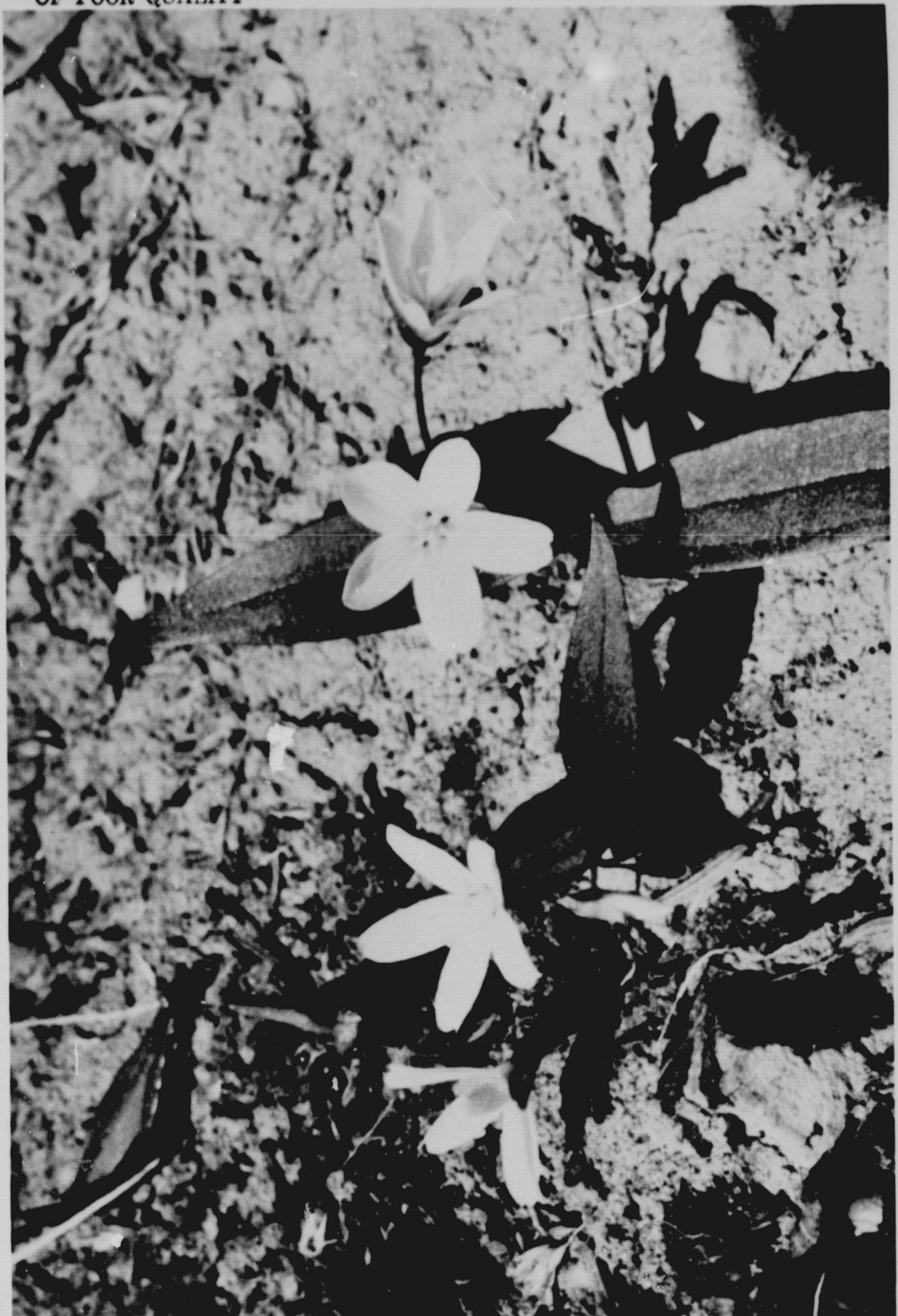
Lomatium cous had a high IVP (5.3) in relation to its random abundance and distribution values of .3 and 4.1%, respectively (Table 18). It was most abundant on calcareous sites, on high ridges, and rock basins. On selected sites in the subalpine zone L. cous had an abundance value of 41.3% (Table 18). Grizzlies showed a decided preference for this plant, locating the high density sites and visiting them annually during late June, July and early August. At such sites, 3 foot x 3 foot (1 m x 1 m) plots averaged 100 tap roots per plot with wet and oven dry weights of 12.5 and 5.3 g, respectively. Forty-six digging areas where grizzlies excavated the starchy roots in the alpine and subalpine zones were .1 acre or larger. Nineteen alpine sites ranged in size from .1 to 40 acres totaling approximately 72 acres. In the subalpine zone, 27 sites ranged from .1 to 160 acres in size, totaling approximately 425 acres.

The Lomatiums have sweet-tasting aromatic tap roots. Grizzlies located them by smell, digging them easily in loose or shallow-soiled sites where they were locally abundant. The leaves, stems and flowers appeared to be eaten incidentally with the root. Where Lomatiums were widely distributed or growing in rock crevices or in heavy alpine turf, they were seldom utilized by grizzlies, probably because the energy output made it unrewarding. Available energy from Lomatium cous was low (2.59), .22 Kcal/g below the caloric average for forbs in general (Table 10). However, it is decidedly a high preference food item. Taste rather than nutrient value may make it attractive to grizzlies.

Claytonia lanceolata

Claytonia lanceolata (Fig. 14) is an early flowering effervescent, blooming about May 1 in the temperate zone and still flowering in the alpine zone by mid-August. It is available for about 4 months in the alpine and sub-alpine zones, but maximum utilization occurred during 2 months when the leaves and stems were still green and succulent. Grizzlies consumed the tuberlike corms, stems, leaves, and flowers. C. lanceolata had an IVP of only 1.2 but the highest caloric value among the forbs (3.94), averaging 1.13 Kcal/g above the forb norm (Table 10). The FPV was 8.8 rating it 11th among the food plants (Table 19). Although very little use was recorded in Scapegoat, we have observed grizzlies feeding on this plant in other areas and recorded numerous digging sites in Yellowstone.

Fig. 14 Claytonia lanceolata.



Evidence from Yellowstone (Craighead in prep. and Mealey 1975) indicate that this plant is a preferred food in the Yellowstone ecosystem. The low recorded utilization in the study area may reflect a higher preference for Claytonia megarhiza and Lomatium cous when they are present. Where the latter two food plants are abundant, C. lanceolata may not be utilized as extensively as would otherwise be the case. Utilization may be higher in the temperate zone in early spring. At high density sites, 3 foot x 3 foot (1 m x 1 m) plots averaged 150 corms (Fig. 15) with wet and oven-dry weights of 34 and 11 g, respectively. This species should rank among the preferred forbs and we would expect evidence of greater utilization over a more extended sampling period.

Polygonum spp.

Traces of Polygonum (Figs. 15 and 16) were identified in feces but P. bistortoides could not be separated from P. viviparum. The former was found in both the alpine and subalpine zones; the latter only in the alpine. The two species were jointly sampled for abundance and distribution. The Polygonums had relatively low IVP, PVP, and random and selected abundance values (Table 17). The

Fig. 15 Photographs showing flowers, corms and roots *Claytonia lanceolata* (above) and *Polygonum bistortoides* (below).

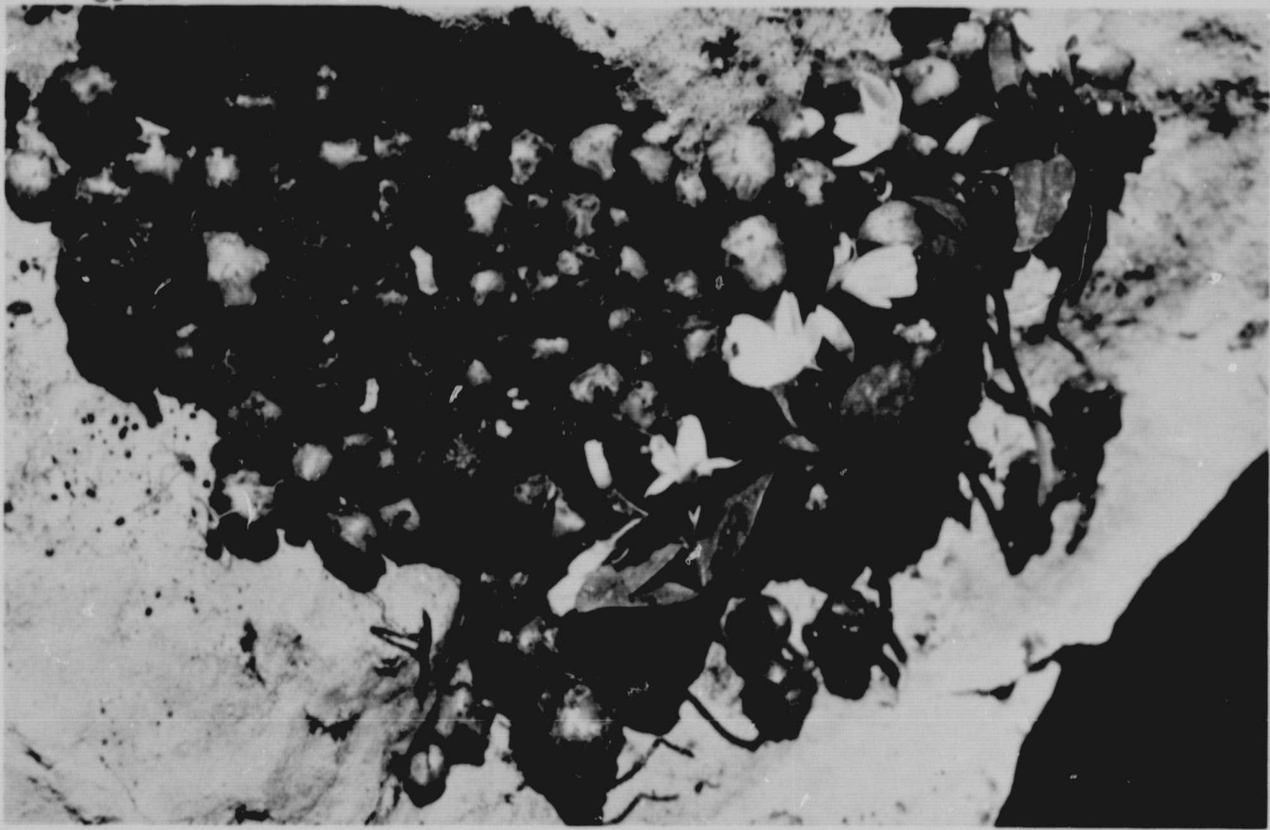


Fig. 16 *Polygonum bistortoides*.

starchy rootstock is palatable but may have been ignored for more highly preferred foods. Energy values were among the lowest for the forbs analyzed. The two Polygonums are normally sparsely distributed and when clustered generally occur in heavy-turfed alpine meadows. Sites where the plant might have been rewardingly excavated in the Scapegoat area were scarce. This and the low energy content may account for its low utilization. Digging sites were rare and all evidence suggests that the Polygonums were not preferred foods in the study area.

Oxyria digyna

Confined almost exclusively to the alpine zone, O. digyna was scarce and sparsely distributed on loose talus slopes and limestone sinks (Fig. 17). Even on such sites it was never found in local abundance. The succulent, acid-tasting leaves and stems are probably highly palatable to grizzlies but were not available in sufficient quantity to form an important item of diet.

Erythronium grandiflorum

Grizzlies consumed the starchy bulbs, leaves, stems, flowers, and seed pods of this early flowering effervescent which bloomed during July and August in the alpine and sub-

Fig. 17 Oxyria digyna.

alpine zones and 2 months earlier in the temperate zone (Fig. 18). The IVP and PVP of .5 and 2.1, respectively do not appear to be consistent with its high caloric (3.63 Kcal/g) and random and selected abundance values of .5 and 15.0% (Tables 18, 19, and 10). All values for this plant suggest that it should have higher importance and preference values in the study area. That it did not, may possibly be attributed to two factors: the leaves are only briefly available, dying soon after seed pods are formed; the starchy bulbs are deep-seated and difficult to excavate compared to the roots, tubers, and bulbs of other available plant foods. At high density sites 3 foot x 3 foot (1 m x 1 m) plots averaged 86 bulbs with wet and oven-dry weights of 80 and 19g, respectively. To excavate the deep-seated bulbs required the removal of nearly four times the volume of earth necessary to excavate corms of *Claytonia lanceolata* and twice the volume required to excavate *Lomatium cous*. The wet weight of edible bulbs greatly exceeded the weight of the fleshy roots and corms of these other plant foods. However, grizzlies infrequently dug the deep-seated bulb of *E. grandiflorum* in the Scapegoat area in spite of its high caloric value of 3.63 Kcal/g (Table 10). We have recorded excavation and

112

Fig. 18 *Erythronium grandiflorum*.

use of the bulbs in Yellowstone National Park.

The young seedpods are succulent and tasty by human standards. Energy values for the leaves and for the seed pods were 3.05 and 2.77, respectively (Table 3 Appendix). At high density sites grizzlies could graze them in quantity with little energy output. We suspect that more sampling will show greater use of the entire plant, especially the seed pods.

Cirsium scariosum

Found in only trace amounts in feces, *Cirsium scariosum* had low random abundance and distribution values and a FPV of only 5.6 (Table 19). No direct or indirect observations were made in the Scapegoat area to indicate that there was heavier use of this plant than indicated by the value obtained from scat analysis. The emerging plant (Fig. 19) is tender, sweet, and extremely succulent; the stems of the mature plant remain sweet and succulent throughout the foraging season. They are a preferred food of elk (Craighead, Craighead, and Davis 1963) and are highly palatable by human standards. The large taproot is easily dug and moderately nutritious as indicated by its caloric value (2.96 Kcal/g) (Table 10). *Cirsium scariosum* was

Fig. 19 *Cirsium scariosum* emerging through snowbank.

heavily used in the Yellowstone ecosystem where it had an IVP of 1.3. In neither area did we find evidence that roots were excavated and eaten, but we suspect that they are and that future sampling will provide conclusive evidence.

Hedysarum occidentale and H. sulphurescens

Two species of Hedysarum, H. occidentale and H. sulphurescens occurred in trace amounts in feces. The large woody rootstocks are not edible by human standards and no grizzly bear digging evidence was recorded. The rootstock of H. occidentale showed a low energy value of 1.98 Kcal/g (Table 10). We observed that the rootstock of Hedysarum alpinum was heavily utilized by grizzlies along the Tatchenshinni, Alsec and other Alaskan rivers. It is less woody than H. occidentale and has a mild licorice falvor. The seed pods of most species are eaten by other mammals, especially rodents, and both the roots and seed pods of the two species found in the Scapegoat area may be more heavily utilized by grizzlies in other areas where more preferred plants are not available.

Juncus spp.

Species of Juncus were far less abundant than the grasses and sedges and occurred only in trace amounts in feces (Table 2). They were probably eaten incidentally when grizzlies grazed grasses and sedges but, like so many of the other food plants discussed, they may show higher sporadic utilization associated with annual phenological and climatic variations. They were not an important food plant in the Sacpegoat area.

Heracleum lanatum

This member of the carrot family grew along streams, in wet meadows, and where the water table was high (Fig 12). Its large tap root and thick, hollow, succulent stems, in young plants, are quite palatable by human standards. The flower buds, which are eaten by mule deer (Odocoileus hemionus) and elk, have an energy value of 3.07 Kcal/g. The stems and leaves have an energy value of 2.53 Kcal/g (Table 10), and the large starchy roots may be even higher. The FPV of 5.5 (Table 19) and our visual evidence of its use, suggests greater usage than is indicated by the fecal analysis. Since black bear, deer and elk also feed on the young plants, grazing evidence is difficult to evaluate. H. lanatum appeared to be more heavily utilized in the temperate than in the subalpine zone; we can not fully evaluate it as a food plant from our data.

Agoseris spp.

These early effervescents were probably too sparsely distributed to form an important diet item. Direct observations of grizzly bears grazing forbs in both the Yellowstone and Scapegoat area indicate that a number of succulent forb species are consumed in small quantities when bears feed on more highly preferred and abundant food plants. Some of these food plants are listed in Section I. Under certain conditions they may assume greater importance than data presented here would indicate.

Xerophyllum tenax

X. tenax did not occur in the sample of feces analyzed but indirect feeding observations and cursory examination of some feces in the field definitely established that grizzlies fed on the leaf bases and seed pods of this plant. However, it was sparingly used in view of its great abundance, seasonal availability, and wide distribution in the subalpine and temperate zones (Table 18). The flowering heads are eaten by elk, mule deer, and horses and have a caloric value of 3.19 Kcal/g (Table 3 Appendix). The grass-like leaves are coarse and unpalatable to most species of wildlife, however, the succulent developing seed pods

Fig. 20 Bulbs of *Melica spectabilis*.

with a caloric value of 3.76 Kcal/g (Table 10) are a preferred elk and mule deer food and may be utilized by grizzlies to a greater extent than our data indicate. The leaf bases of this perrenial showed a caloric value of 2.27 Kcal/g (Table 10) which is higher than the average energy value for grasses (2.14 with *Melica* bulbs excluded) (Table 18). Thus, it may serve as an emergency food available to grizzlies when other plant foods are not. The central growing "core" of leaves is easily extracted exposing the white, tender leaf bases. Grizzlies could obtain large quantities of this food with relatively little expenditure of energy.

Miscellaneous Forbs and Grasses

Data from radiotracking grizzlies in Yellowstone showed heavy utilization of *Trifolium* spp., *Melica spectabilis* (Fig. 20), and *Perideridia gairdneri* (Craighead J.J. in prep.). Mealey (1975) also found heavy use of these forbs by grizzlies. Species of *Trifolium* were not confirmed as food items in the alpine and subalpine zones of the study area either by scat analysis or through field evidence. However, *Trifoliums* were abundant along well-used trails and in the moist meadows of the temperate zone and we found field evidence that they were utilized there.

P. gairdneri had a selected abundance value of only 5.0 in the subalpine grasslands, but was very abundant in the grass-shrublands of the temperate zone where its selected abundance value was 40.0%. It can produce a greater biomass of high energy food than any other forb whose underground parts were sought and consumed by grizzlies. At high density sites, 3 foot x 3 foot (1 m x 1 m) plots averaged 176 tubers with wet and oven-dry weights of 160 and 55g, respectively. P. gairdneri is highly palatable by human standards and was a high preference food plant in Yellowstone (Craighead J.J. in prep.). The tubers can be excavated with relative ease. P. gairdneri had a higher energy value (3.61 Kcal/g) than any other forb tested - 80 Kcal/g above the forb caloric average (Table 10). Because we had no IVP or a PVP for this plant we could not calculate a food plant value (FPV). It is heavily utilized in other areas, and no doubt was eaten by grizzlies in our study area, but was probably undetected because the temperate zone, where this plant is most abundant, was not systematically sampled for scats or for feeding sign.

Berries

Berries are more highly preferred than any other plant food category with the possible exception of pine nuts (Table 19). Their average caloric value of 3.21

(Table 12) is higher than that for grasses and sedges but lower than that for pine nuts. Energy values ranged from a high of 3.52 Kcal/g for Vaccinium scoparium to lows of 2.82, 2.73, and 2.72 for Arctostaphylos uva-ursi, Prunus virginiana, and Rosa spp., respectively (Table 10). Berries are less consistent and dependable as an energy source than the graminales and forbs. All species in the area exhibited extreme temporal and spacial fluctuations in fruit production emphasizing the importance of species diversity as a parameter of bear habitat. Annual availability of berries is largely dependent on this diversity.

We made no attempt to quantify berry production, however, it was obvious from general field observation that production of all berry-producing species varied temporally and geographically. The fact that low annual production by one species was offset by high production in another only seemed to emphasize the importance of a diverse flora that would tend to dampen otherwise extreme mono-species occilations in fruit production. For example, berry production for Vaccinium globulare (Fig. 21) was high in the Scapegoat study area only one year in five. When production by this species was lowest, V. scoparium

Fig. 21 Fruits of *Fragaria virginiana* (above) and *Vaccinium globulare* (below).

(Fig. 22) was average or better. In 1976 when production by both species was considered low, production by *Shepherdia canadensis* (Fig. 22) and *Fragaria virginiana* (Fig. 21) were high. Good light conditions are necessary for fruit production in *Vaccinium* spp. Forcella and Weaver (1977) showed a relationship between berry production of *V. scoparium* and increasing canopy coverage. Production was greatest and less variable in open-canopied forests, natural openings, and ecotones between the forest and in the open grass-shrublands. Shading effect in the dense-canopied forests reduced production. To better understand and define the role of berry producing plants, berry production in grizzly bear habitat must be quantitatively measured over a period of years.

As mentioned earlier, feces composed of berries are difficult to find and collect because they deteriorate more rapidly than scats composed of other plant food items (see METHODS); and they are frequently dropped in heavy shrub cover. Thus, our sample size for scats containing berries was relatively small and therefore, we believe, biased compared to those for grasses and forbs. Consideration has been given to this in the evaluation process.

Fig. 22 Photograph showing the berries of two important grizzly bear food plants; *Vaccinium scoparium* (left) and *Shepherdia canadensis* (right).

Arctostaphylos uva-ursi

A. uva-ursi exhibits extremes in berry production. When abundant its berries are an important diet item of the grizzly bear, although the energy value is relatively low (2.82 Kcal/g) (Table 10). They are among the most available of all berries found in the habitat of the grizzly. This is due to the abundance, and wide distribution of the species (Table 17), and to the persistence of its berries throughout the bears' foraging season, lasting even through the winter. Like *Xerophyllum tenax*, the berries of *A. uva-ursi* were available when many other plant foods were not.

Ribes spp.

The berries of all species of *Ribes* were utilized by grizzlies and, no doubt, can be important diet items where the plants are abundant and during years of high berry production. The Kcal/g are high, 3.30 and 2.94 for *R. cereum* and *R. lacustre*, respectively (Table 10); but the random abundance values were exceedingly low (Table 18). Nowhere and at no time on the study area were currants abundant; the berries of all *Ribes* species were minor diet items, However, in parts of Alaska we have noted intensive use of various species of *Ribes*.

Vaccinium scoparium and Vaccinium globulare

In analyzing feces, we did not differentiate between berries of V. scoparium and V. globulare (Figs. 22 and 21). They had a combined IVP of 5.4 with a FPV of 42.7 (Table 19). They ranked third in importance as a plant food category. Their random and selected abundance as well as distribution and caloric values were high. The great local and temporal variations in berry production make the Vacciniums less reliable than the graminoids as a food source, but, during years of good berry crops, grizzlies may feed exclusively on them. At such times, grizzlies gain weight rapidly. Berries are primarily summer foods but when abundant, they are utilized through autumn. Infrequent observations were made of grizzlies feeding on Vaccinium berries because they foraged primarily in the brushy burns and in forest areas of the temperate and subalpine zones where visibility was poor. Grizzlies began feeding on berries in mid-July in the temperate zone then followed the cycle of ripening berries altitudinally until frosts and snows rendered them unavailable. Our observations of radio-instrumented bears in Yellowstone and observations made by Douglas Peacock (NPS employee) in the Apgar mountains of Glacier National Park support our observations in

Scapegoat; that *Vaccinium* berries are an extremely important diet item. In Yellowstone *V. scoparium* and *V. membranaceum* had a combined importance value percent of 7.2. We conclude that, in spite of fluctuating levels in berry production, *Vacciniums* are such essential components of grizzly bear habitat, that widespread modifications or destruction of this energy source would have critical effects on a population.

Shepherdia canadensis

Shepherdia canadensis had an IVP of 3.5, a PVP of 10.4, and a FPV of 19.4 (Table 19). These values appear high considering the shrubs' low random abundance and distribution values, Tables 18 and 19. The caloric value of 3.26 (Table 10) was higher than most berries tested. The selected abundance value of 26.7 (Table 18) and evidence of berry stripping along trails suggest that grizzlies probably utilized the high caloric fruits wherever they were abundant. Feeding observation indicated the berries (Fig. 22) were easily stripped because of their clumped arrangement. Although the berries of *S. canadensis* have a lower preference value than the Vacciniums, they undoubtedly serve as an important reserve of summer food in years when the highly variable *Vaccinium* berry crops are poor. *S. canadensis* provided a diversity of diet in habitats where the Vacciniums were a predominant ground cover and food producer. In this role, the species may be far more important than its IVP or PVP indicated. We noted heavy use along Alaskan rivers during a summer when berries were very abundant.

Fragaria spp.

Berries of *Fragaria virginiana* (Fig. 21) appear to be relatively important as indicated by the values in Tables 18 and 19. They had an IVP of 2.0 in Scapegoat and 4.8 in the Yellowstone ecosystem. The random abundance levels indicate that bears could use this food source advantageously only when they located high density stands in years of good berry production. High strawberry production was recorded only one year in five. This occurred in 1976 when *Vaccinium* production was low. To evaluate the availability of strawberries to a foraging grizzly, we recorded the time required for a man to gather a pint at high abundance sites during the peak year of 1976 (Table 16). It required 30 minutes to pick a pint. In contrast 340 minutes were required when production was very low. The results suggest that a grizzly can rapidly fill its stomach under the most favorable conditions. However, it rarely gets an opportunity to do so in the study area because of the plants' low random abundance value and highly erratic berry production.

Rubus spp.

Species of *Rubus idaeus* and *R. parviflorus* were poorly represented in the study area and their berries formed only an incidental diet item.

Lonicera spp.

The Loniceras were represented by *L. involucrata* and *L. utahensis*. Neither species was abundant; their berries were considered incidental items of diet.

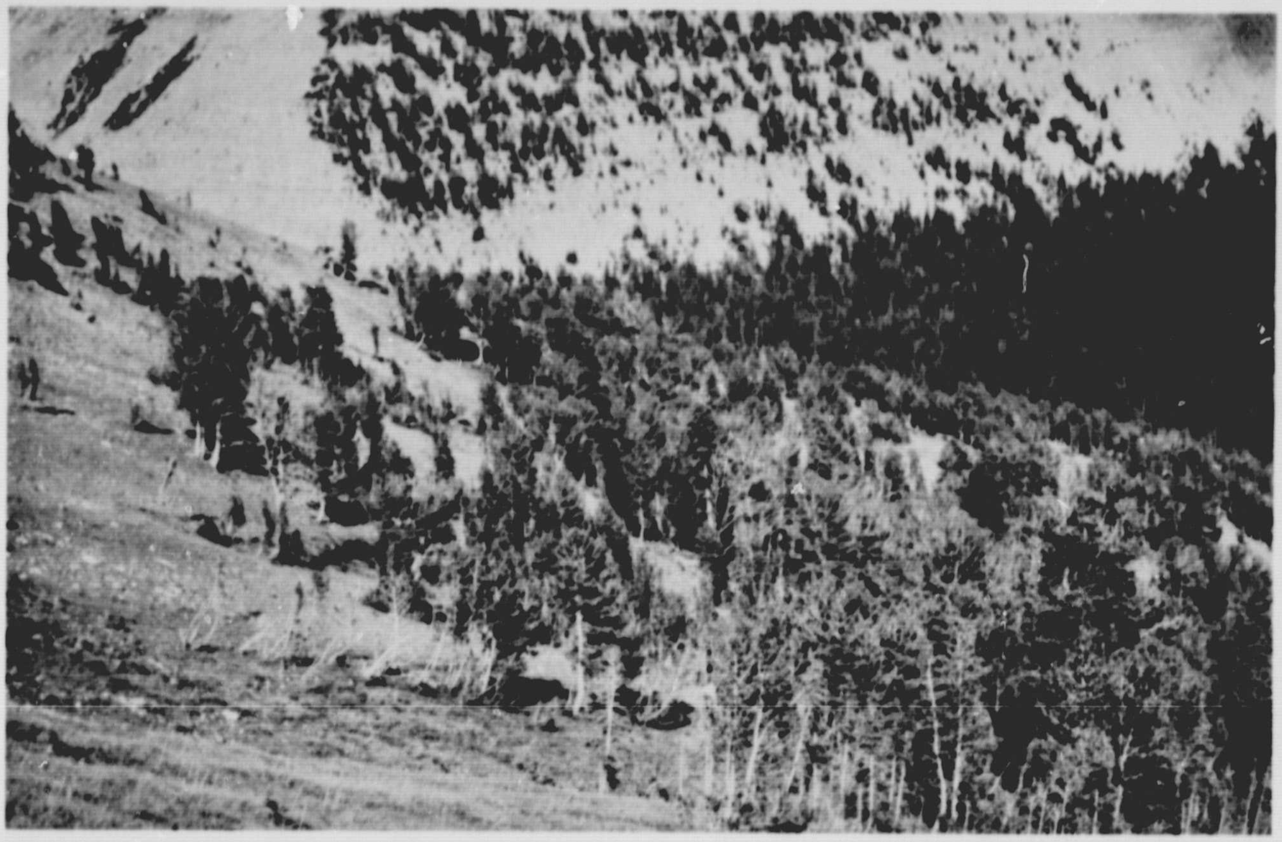
From the low diet evaluations for species of *Rubus* and *Lonicera* and from the lack of any fecal evidence for utilization of *Sorbus scopulina*, *Cornus stolenifera*, *Cornus canadensis*, *Berberis repens*, *Symphoricarpos albus*, *Sambucus racemosa*, *Prunus virginiana*, as well as berries of *Smilacina stellata*, *Streptopus amplexifolius*, *Rosa asicularis*, *Cornus canadensis*, *Clintonia uniflora*, and *Disporum trachycarpum* it cannot be interpreted that the fruits of these plants were not eaten by grizzlies. Their foraging habits are such that probably all of them were consumed infrequently and in small quantities. With more intensive long-term fecal sampling an IVP could possibly be calculated for each species of Lonicera. We reemphasize that the real value of the relatively scarce fruits is the diversity of diet they afford the omnivorous grizzly and the supplement they provide to the staple diet items at times or in places of general food scarcity.

Pine Nuts

Pinus albicaulis, with the highest FPV of any single food plant (50.2) was so abundant and so widely distributed in the subalpine zone that its seeds provided a major food item (Table 19 and Fig. 23). However, *Pinus flexilis* was rare on the study area, and we have discounted its seeds as an item of diet. On the slopes and ridges bordering the high plains east of the Scapegoat study area, this species was represented in the *Pinus flexilis/Agropyron spicatum*, *Pinus flexilis/Festuca scabrella*, and *Pinus flexilis/Juniperus communis* forest habitat types. There at elevations between 4,400 and 6,600 feet it is an ecological equivalent of *P. albicaulis* and an important energy source for grizzlies.

Forcella and Weaver (1977), estimating on a unit area

Fig. 23 *Pinus albicaulis* forest (above); nuts and cones of *P. albicaulis* (below).



basis, showed a 6-8 year cone and seed production sequence for P. albicaulis. Cone crops varied greatly between stands and between years in any given stand, with an equal number of "good" and "poor" cone crop years within each stand. Variations in cone crops also occurred between branches within a tree, trees within a stand, and stands within a geographic region. Mean cone productivity was correlated with arboreal canopy coverage. Seed crops varied from 0 to 600 (0-60g) per square inch per year. Forcella concluded, "that the cone and seed crops of P. albicaulis are as great or greater in both mass and number than those of any other pine species." As such they provide a larger and perhaps more consistent energy source for grizzly bears than the variation in seed production would indicate. For example, the large size of grizzly bear home ranges (Craighead, F.C. 1976 and Craighead, J.J. 1978) may ensure that during years of poor productivity, some stands within a bear's home range may produce seeds. The high IVP and preference values of 20.4 and 17.6, respectively (Table 19), suggest that bears selectively seek pine nuts even during years of low seed production. With a caloric value of 3.99 Kcal/g (Table 10), and random and selected abundance values of 17.0 and 91.0% (Table

18), respectively, they were by far the most important diet item derived from a single plant species.

Scats composed of pine nuts, husks, resin, and cone scales (like those composed of grasses and sedges) are very durable to weathering and thus may be over-represented in the total fecal sample. Nevertheless, the importance of P. albicaulis as a component of grizzly bear habitat and of its seeds as a diet item can hardly be overemphasized.

Grizzlies obtained pine cones by locating them on the ground after abscission, by excavating clusters of nuts or seedlings from the forest litter after the seeds had separated from the cone axis, and by robbing rodent caches. Occasionally, cones were pulled from the lower limbs before abscission occurred, then bears consumed the entire cone; scales, resin, cone axis and seeds. Normally, seeds were not available in the spring, but following a good crop, bears found them in caches and under the forest litter and they then became an important item of the spring diet.

DISCUSSION

Quite a wide range of food plants are available to the grizzly bear throughout the three climatic zones. They have been arranged into four energy categories: grasses and sedges, forbs, berries, and nuts. A few species in the two latter categories, e.g., *Vaccinium globulare*, *V. scoparium*, *Shepherdia canadensis*, and *Pinus albicaulis*, are essential components of the diet because of their high energy and preference values. The grasses, sedges, and forbs, though of lower energy value, are also important because of their high availability both temporally and spatially.

Those portions of the grizzly bears' total environment that contain preferred food plants in greatest abundance are critical to the bears' welfare. Some of these, such as seepage areas where *Equisetum arvense* grows in heavy mats are small in size; others, such as the *Abies lasiocarpa*/*Luzula hitchcockii* habitat type *Vaccinium scoparium* phase where grouse whortleberry may average 50% of the forest understory, are quite large. Some critical food source areas are at high altitudes, e.g., the semi-vegetated talus which supports *Claytonia* *megarhiza* and the glacial cirque basins with *Lomatium cous*, while others such as the sedge marshes and the forest habitat type *Abies lasiocarpa/Xerophyllum tenax-Vaccinium scoparium* phase lie near the lower altitudinal limits of the bears' wilderness environment. The former areas provide succulent vegetation in early spring; the latter, where 86% of the ground cover may be plants eaten by grizzlies, are a veritable store-house of various plant foods.

The wide range of food plants available to grizzly bears and their omnivorous feeding habits do not necessarily ensure them an adequate food supply from year to year. During years of widespread failure of such preferred food as *Vaccinium* berries and/or pine nuts, grizzlies generally must travel more, enlarge their home ranges, visit man-made sources of food more frequently, and will exhibit greater aggressiveness in defense of their food sources (Craighead, J.J. in prep.). Which of the less preferred food plants grizzly bears will eat, and how much of these they eat, depends greatly on the degree of fluctuation in abundance of the berries and pine nuts, as well as on the availability of animal protein. Therefore, to put the plant base of the bears'environment in perspective, it is necessary to describe briefly the bears' metabolic stages and to show how these influence the grizzly's utilization of the diverse elements of its environment, temporally and spatially, traveling between areas of food abundance.

Basically a carnivore, the grizzly prefers a meat over a vegetable diet; nevertheless, it is dependent on vegetation for perhaps half of its dietary requirements. In years when berries and nuts are scarce, grizzlies sustain themselves with green vegetation (grasses, sedges, and forbs), but generally will lose weight because these foods are not completely digested. Grizzlies feeding primarily on green vegetation in spring fail to gain weight, but those that secure high protein food such as carcasses, the young of big game species, or find various man-made food sources, hold their weight levels or gain weight. When pine nuts are abundant, grizzlies gain weight rapidly from this high energy plant food. A young adult male killed early in the spring following an exceptionally good pine nut season had 5½ inches of fat over the rump. The excellent condition of individual Yellowstone bears captured and weighed in September and October correlated well with good crops of pine nuts (Craighead, J.J. in prep.). Similarly, grizzlies gained weight in those summers when berry crops were good.

Grizzlies evidence different metabolic stages (exhibited in terms of nutritional status) that are associated with seasonal changes. Nelson (et al. in prep.) has described four metabolic stages for the black bear: 1) hibernation or winter sleep, 2) transition or hypophagia, 3) normal activity, and 4) hyperphagia. We have determined that these metabolic stages in the grizzly are closely attuned to plant and animal phenology and can be observed and documented in the behavior and activity of a bear population.

In spring when adult grizzlies leave their winter dens, they eat sparingly for several weeks (hypophagia). Their movements are generally slow and deliberate. During this transition stage from hibernation to normal activity, they continue to metabolize body fat. As food becomes increasingly available, the bears' food consumption increases. Our observations of feeding behavior and our weight records taken in Yellowstone, suggest that during April and May losses in body weight may exceed gains as grizzlies continue to utilize body fat (Craighead, J.J. in prep.). By June, grizzlies are on a normal feeding regime (stage 3) involving a wide range of foods, but they still exhibit little or no gains in body weight. Not until late July and August are there noticeable increases in body weight associated with the seasonal increase in food quality and availability.

From mid-July through September a maximum amount of food (energy) is present from both plant and animal sources. Bears spend much of their time feeding (hyperphagia) and gains in body weight are spectacular. Among 28 individual grizzlies that we captured and weighed periodically in Yellowstone, a 2-year-old female showed an average weight gain of 3.63 pounds per day over a 24-day period from mid-July to mid-August; a yearling male, 2.14 pounds per day over a similar time span; and one adult female, 2.50 pounds per day over a 26 day period. Bears for which weights were averaged over longer time spans of 111, 114, and 118 days showed gains of 0.90, 0.53, and 1.02 pounds per day, respectively. In adults, the rapid weight gains are due largely to fat deposition, but in subadults, lean body mass also increases. The average annual increase in weight of yearlings was 145% for males and 130% for females.

As winter nears, metabolic changes occur which serve to prepare the grizzly for winter sleep (stage 1). Among well-fed members of a population, feeding activity decreases in mid-October and some of these animals will exhibit a state of lethargy before entering winter dens (Craighead, F.C. and J.J. Craighead 1972). Those animals not so well-fed may continue to feed up to the time they enter their dens for winter sleep. In Yellowstone, for example, we observed color-marked animals that moved almost daily from den areas to feed on elk carcasses. They terminated feeding only when heavy snow storms finally confined them to the dens.

Grizzlies hibernate from October/November to March/April, a period when both plant and animal foods are unavailable. Normally grizzlies remain in the dens throughout the winter (Craighead and Craighead 1972). However, we recorded several instances in Yellowstone where adult grizzlies left dens in mid winter when ambient temperatures rose and mild weather prevailed for 5 to 6 days. There was no evidence that grizzlies fed while on these excursions away from their dens. While in the den, grizzlies metabolize stored body fat (Folk et al. 1972). This requires no intake of free water and produces no wastes requiring defecation or urinary excretion. However, water is expelled through respiration. Body fat remains the sole ultimate energy source until late March or April (Nelson et al. in prep.). At this time, all members of a population except females with cubs will normally leave the dens.

The transition from fat to carbohydrate/protein metabolism (stage 2) takes place slowly, in association with behavioral and activity patterns that are observable and with changes in physical condition that are measureable. By mid-May to mid-July, the bears have again become active, exploiting all of the energy sources available to them. At this time, adult females come into estrus and the larger, more aggressive males breed them (Craighead et al. 1969). Agonistic behavior is common among adult males; we have observed many severe encounters during the mating period. It is a time of great energy expenditure by all members of a population. The relatively low energy intake and high energy utilization is reflected in the nutritional level of the population. Body weights of individual animals reach an annual low.

The 6 to 7 month period from den emergence to return is, in general, one of preparing for hibernation. The bears' physiology and its behavior reflect this constant preparation for hibernation, hibernating, or recovering from hibernation. The entire year is defined in this cyclic phenomenon of metabolic stages that dictate the bears' behavioral patterns, especially those associated with foraging and feeding.

Most of the grizzlies' foraging movements are deliberate. Information obtained during ten years of observing color-marked, as well as radio-collared, grizzlies of all ages and both sexes in the Yellowstone ecosystem (Craighead, J.J. 1978 and Craighead, J.J. in prep.) showed that individual grizzlies do not normally move randomly or aimlessly throughout their large home ranges, feeding opportunistically; rather, the bears are attuned to the plant phenology and the animal activities associated with the emergence and maturation of plants.

From the Yellowstone study, and that in the Scapegoat, we can describe a general pattern of movement and activity in terms of operations for securing food. Some bears leave their hibernation dens as early as March, traveling when the snow is crusted or keeping to the bare south-facing ridges. They move from the subalpine zone where they have denned to the lower subalpine and the temperate zone where snow is light or absent. By late April to mid-May, many of the mature bears and most of the subadults have moved from winter dens to the lower altitudes. Females with cubs of the year may emerge from late April to late May, and they, too, tend to move to lower altitudes. At this time, over-wintering rodents such as Microtus spp., Peromyscus spp. and Thomomys talpoides are captured and consumed. High over-wintering populations of these rodents occur periodically. At such times we found them to be especially vulnerable as the snow cover melted. A female and three yearlings were observed to feed for several weeks on Microtus spp. During this time, these rodents constituted a significant portion of the total diet of this family group. Where big game is abundant, grizzlies move to the winter ranges and feed on winter-killed animals or prey on those in a state of advanced malnutrition. Grizzly bear predation on big game species is generally greatest from mid-April to mid-May. At the periphery of the wilderness, they may kill livestock or feed on livestock carrion. Often more than one grizzly may feed on a carcass. We have records of 172 grizzly bear sightings on 118 big game carcasses over a 13-year period in Yellowstone. Carcasses were usually visited before the snow had melted. Sometimes as many as 6-7 individiual grizzlies utilized a carcass, and there were instances in which carcasses were periodically revisited for 10 to 15 days. One grizzly returned to a carcass at least 9 times during a 15 day period.

Where food is abundant and concentrated, aggregations of bears occur and a social order is operative (Craighead and Craighead 1971, Craighead, J.J. 1978, and Hornocker 1962). The social hierarchy serves to increase foraging efficiency by allowing large numbers of a population to share a common food source. In Yellowstone we recorded up to 23 grizzly bears feeding on a bison (Bison bison) carcass and documented aggregations at open pit garbage dumps (Craighead and Craighead 1971). Grizzlies supplement an early spring meat diet with the early emerging sedges and grasses. As big game species leave winter ranges and move to higher elevations, the bears tend to follow the same pattern, feeding primarily on grasses and forbs. If carrion or other high protein food is not available, they sustain themselves almost exclusively on the plant resource. Adult males, the subadults of both sexes, and females without offpsring are generally solitary foragers. Females with cubs, yearlings, or two-year olds forage as family groups. A female with cubs may form a close bond with a similar age family which then travels and forages as a unit.

In early June elk begin dropping their calves in the temperate and subalpine parklands. Calving sites tend to be traditional, the elk returning to them year after year. Grizzlies, whose home ranges encompass these calving areas, appear to locate them by scent. They follow elk as they migrate to these areas. In some instances, individual bears apparently recall the locations from past experience. Calves are highly vulnerable to grizzlies for a relatively short period of time. Soon after calving, the cows and their offspring move to higher elevations, their movements determined by the recession of snow and the emergence of plants. Grizzlies follow the same general pattern so that by July they are feeding on the grasses, sedges, and forbs in both the subalpine and alpine zones.

From late June through July, the alpine zone is used extensively as a source of Lomatium cous, Claytonia megarhiza, and other succulent and nutritious tubers, bulbs, and greens. Insects become important items of diet during this period. Grizzlies seem to have a craving for such insects as moths, beetles, ants and even earthworms that is partially, but not entirely, related to their high protein content.

As August approaches, the berries of *Vaccinium scoparium* and *V. globulare* begin to ripen in the temperate zone and those of *Shepherdia canadensis*, in the subalpine. Grizzlies traveling within large, but undefended, home ranges, move to lower elevations to utilize this energy resource, which, in years of peak abundance, is exploited until snow covers the subalpine country. When berries are abundant, bears tend to utilize this food source almost exclusively and gain weight rapidly. In years when berry crops are poor, the greens supplement the energy shortage, but bears do not gain weight on this diet. At such times the nuts of the whitebark and limber pines (*Pinus albicaulis* and *P. flexilis*) become a critical energy source. Grizzlies will move to the extremities of their home ranges to feed on pine nuts and will utilize them through September, October, and in some instances, until mid-November. We have radio-tracked grizzlies that moved over 50 airline miles to feed on whitebark pine nuts. In the Yellowstone ecosystem, and in the Scapegoat study area as well, the nuts of whitebark pine provided the high energy diet necessary for the grizzly to enter hibernation with a heavy layer of stored fat. Bumper pine nut crops occurred twice throughout Yellowstone over a 12-year period and twice over a 7-year period in Scapegoat.

Stored fat is vital to the bears' survival. During the long period of hibernation (a winter sleep of approximately 5 to 6 months) it is the bears' only energy source. Most grizzlies leave their dens with sufficient body fat to carry them through the lean months of spring. Females with cubs reach a lower nutritional level than other members of a population because energy reserves are expended to give birth to young and to produce milk. Lactating females may not show renewed fat deposition until late August or September. We have evidence that the degree of fat deposition in fall may influence the estrus cycle and thereby determine whether a female will wean her cubs as yearlings or carry them through another year (Craighead, J.J. in prep.). When both berry and pine nut crops peak, grizzlies fare exceedingly well. During a 12-year period this ideal situation never occurred uniformly throughout the Yellowstone ecosystem, but did occassionally occur within specific home ranges of individual bears.

Grizzlies locate and learn to use specific locales where plant and animal foods are most abundant. The more productive sites become centers of activity within home ranges (Craighead, J.J. 1978). In the course of a long life span, such areas become well-known to individual bears. Whether these and other portions of the bears' environment are large or small, at high or low elevations; or whether they support many or few bear food plants, they are all parts of larger vegetation units that the grizzly utilizes throughout the year with an uncanny sense of its biological needs and a knowledge of where it can meet its dietary requirements.

To manage grizzly bears and their habitat more precisely it is imperative that these components of the bears' enivronment be mapped and quantified throughout an entire ecosystem. We believed these larger units of vegetation (Vegetation Complexes) could be mapped with electronic scanning and digital data recordings from staellites.

We hypothesized that this could be accomplished by applying remote sensing techniques to the data base just presented as well as that for Section I, Vegetation Description of Grizzly Bear Habitat in the Scapegoat Wilderness. If successful, the methodology would provide an entirely new approach to planning, inventorying, and managing wilderness resources. Of more immediate concern, the results could be used to assist the recovery of a threatened species. The utilization of LANDSAT imagery and computer science to map, quantify, and evaluate habitat of the grizzly bear in the Scapegoat and Bob Marshall Wilderness areas will be the subject of Section III.

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APPENDIX

APPENDIX

Table 1 Calculation of Bear Food Plant Values for the alpine zone.

Food Plants	Importance Value Percent (IVP)	Preference Value Percent (PVP)	Random Abundance Value	Energy Value Percent (EVP)	Food Plant Value (FPV)
Berries					
Arctostaphylos **uva-ursi**	1.6	2.1	1.5	2.4	7.6
Plant group	1.6	2.1	1.5	2.4	7.6
Mean values	1.6	2.1	1.5	2.4	7.6
Forbs					
Claytonia megarhiza	5.5	5.7	.1	2.1	13.4
Lomatium cous	5.3	12.8	.2	2.7	21.0
Claytonia lanceolata	1.2	2.1	T	3.3	6.6
Polygonum spp.	.9	2.0	.3	2.0	5.2
Erythronium grandiflorum	.5	2.1	.3	3.0	5.9
Hedysarum spp.	.1	---	.4	1.7	2.2
Cirsium scariosum	.1	---	T	2.5	2.6
Heracleum lanatum	.1	---	T	2.1	2.2
Plant group	13.7	24.7	1.3	19.4	59.1
Mean values	1.7	3.1	.2	2.4	7.4
Graminales					
Gramineae	25.9	7.0	5.5	1.8	40.2
Cyperacea-	3.8	4.6	5.0	1.9	15.3
Plant group	29.7	11.6	10.5	3.7	55.5
Mean Values	14.9	5.8	5.3	1.9	27.8
Sum of Food Plant Parameters	45.0	38.4	13.3	25.5	122.2

Zone Composite Value Percent = Sum of FPVs

Zonal Index = $\frac{\text{Sum of FPVs}}{100}$ = 1.22

APPENDIX

Table 2 Calculation of Bear Food Plant Values for the subalpine zone.

Food Plants	Importance Value Percent (IVP)	Preference Value Percent (PVP)	Random Abundance Value	Energy Value Percent (EVP)	Food Plant Value (FPV)
Berries					
Vaccinium spp.	5.4	18.7	6.6	2.8	33.5
Shepherdia canadensis	3.5	10.4	.1	2.7	16.7
Fragaria virginiana	2.0	2.6	.4	2.5	7.5
Arctostaphylos uva-ursi	1.6	2.1	T	2.4	6.1
Plant group	12.5	33.8	7.1	10.4	63.8
Mean values	3.1	8.5	1.8	2.6	16.0
Nuts					
Pinus albicaulis	20.4	17.6	7.9	3.3	49.2
Berries and Nuts combined					
Plant group	32.9	51.4	15.0	13.7	113.0
Mean values	6.6	10.3	3.0	2.7	22.6
Forbs					
Lomatium cous	5.3	12.8	.1	2.2	20.4
Equisetum arvense	2.3	.9	.3	2.2	5.7
Claytonia lanceolata	1.2	2.1	.2	3.3	6.8
Polygonum spp.	.9	2.0	.1	2.0	5.0
Erythronium grandiflorum	.5	2.1	.3	3.0	5.9
Heracleum lanatum	.1	---	.3	2.1	2.5
Cirsium scariosum	.1	---	T	2.5	2.6
Hedysarum spp.	.1	---	.1	1.7	1.9
Plant group	10.5	19.9	1.5	19.0	50.8
Mean values	1.3	2.5	.2	2.4	6.5
Graminales					
Gramineae	25.9	7.0	4.6	1.8	39.3
Cyperaceae	3.8	4.6	4.6	1.9	14.9
Plant group	29.7	11.6	9.2	3.7	54.2
Mean values	14.9	5.8	4.6	1.9	27.1
Sum of Food Plant Parameters	73.1	82.9	25.7	36.4	
Zone Composite Value Percent = Sum of FPVs					218.0

Zonal Index = $\frac{\text{Sum of FPVs}}{100}$ = 2.18

**Average canopy cover for P. albicaulis in the subalpine forest (36.4% of study area) was 17.0%. The temperate forest represented 42.1% of the study area with, characteristically, no P. albicaulis. The overall value of P. albicaulis for all forest, then, was 7.9%.

APPENDIX

Table 3 Chemical analysis and caloric values of grizzly bear food plants. 1980.

Bear Food Plant	No. Samples	Protein Percent	Protein Kcals/g	Ether Extract Percent	Ether Extract Kcals/g	Nitrogen Free Extract Sugars %	Nitrogen Free Extract Non-Sugars %	Total Nitrogen Free Extract Percent	Total Nitrogen Free Extract Kcals/g	Percent Total Kcals/g
Erythronium grandiflorum (leaves and stems)	1	11.1	.48	5.1	.48	12.1	37.7	49.8	2.09	3.05
Osmorhiza occidentalis (leaves and stems)	1	15.2	.65	2.1	.20	7.1	41.1	48.2	2.02	2.87
Heracleum lanatum (flowering heads)	1	26.3	1.13	3.8	.36	3.9	33.8	37.7	1.58	3.07
Xerophyllum tenax (flowering heads)	1	21.1	.91	2.1	.20	9.1	40.4	49.5	2.06	3.19
Thalictrum occidentale (newly emerging leaves)	1	24.4	1.05	6.0	.56	5.9	37.0	42.9	1.80	3.41
Erythronium grandiflorum (seeds and seed pods)	1	15.5	.67	2.5	.24	6.0	38.3	44.3	1.86	2.77
Cirsium scariosum (stems and leaves)	1	14.9	.64	2.2	.21	3.6	36.8	40.4	1.70	2.55
Festuca idahoensis (before heading out)	1	13.1	.56	3.4	.32	6.3	38.7	45.0	1.89	2.77
Festuca idahoensis (before heading out)	1	10.5	.45	3.3	.31	7.8	38.9	46.7	1.96	2.72